Churches and Chapels.

KIDDER

CHURCHES AND CHAPELS.

THEIR ARRANGEMENTS, CONSTRUCTION AND EQUIPMENT
SUPPLEMENTED BY
PLANS, INTERIOR AND EXTERIOR VIEWS OF NUMEROUS
CHURCHES OF DIFFERENT DENOMINATIONS,
ARRANGEMENT AND COST.

200 ILLUSTRATIONS.

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Fellow of American Institute of Architects. *Author of "The Architects' and Builders' Pocket Book," "Building Construction and Superintendence." Etc.*

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AUTHOR'S PREFACE.

THE success attending the first edition of this work, and the lack of practical books treating of the arrangement, construction and equipment of churches has induced the author to extensively revise the original edition, so as to greatly extend its scope, and thereby increase its value, both to architects and to building committees.

The aim of the author has been to furnish such information as will be of practical assistance to the architect in preparing the plans and specifications, and to the building committee in deciding upon the general arrangement best adapted to their needs, and how best to equip the building.

The great and rapid extension of the work and scope of the non-liturgic churches that has taken place during the past twenty-five years and the multiplicity of societies and auxiliaries has led to many innovations and conveniences in the modern church which are still unfamiliar to those who have not kept in touch with the advance work of the church and its auxiliary branches, and an attempt has been made to show the different ways in which these new requirements have been met. Attention has also been called to many little details of arrangement or equipment, which affect the comfort of the audience or which enable the work of the church and its branches to be more effectually or conveniently conducted.

As the question of cost is nearly always a very important consideration in the planning of churches, and often a controlling one, the author has endeavored to point out those features which are especially expensive and to show what arrangements will give the most commodious and convenient building at the least expense. While it is true with churches, as with other buildings that the best construction and the most artistic design is usually the most expensive, yet by understanding what arrangement of floor plan is the most economically constructed and roofed, and why certain details of construction or ornament are much more costly than others that give very nearly the same general effect, the architect will be able to design a building that will meet the needs of the society, and which can be erected for a much smaller sum than would be the case were these matters not fully considered.

With regard to the architectural expression of the building, the author has said but little, and that merely in a general way. Whether the design will be good or bad will depend almost entirely upon the capacity of the architect to give a proper expression to the building, limited to a greater or less degree by the site and the dictations of the building committee.

To illustrate the descriptions of arrangements, equipment or construction numerous engravings have been inserted in the text.

These have been prepared with the view of furnishing suggestions to the architect or layman rather than for the artistic effect. The plates at the back of the book illustrate nearly every arrangement commonly found in modern Protestant churches in this country.

Most of the plans are of existing buildings, and when not built from the author's designs the name of the architect has been given. In most instances the dimensions of the building and seating capacity are given, and in some cases the cost.

In closing the author wishes to acknowledge his indebtedness to Messrs. L. B. Valk & Son and Geo. W. Kramer, architects, for the use of drawings and photographs, and to the publishers of the American Architect and Building News and the Bates & Guild Co. for permission to use certain of their illustrations.

PUBLISHER'S NOTE.

In presenting the third edition of this work the publisher regrets to announce the death of the author.

The last proofs of the book were approved by Mr. Kidder shortly before he entered the hospital for the operation which unfortunately resulted in his death.

The whole revision of the work had received his careful attention, and at his death there only remained for the publisher to carry out his ideas. A number of new designs have been added, notably plans for Catholic churches and a more elaborate description of their requirements, as well as that of the Episcopal church.

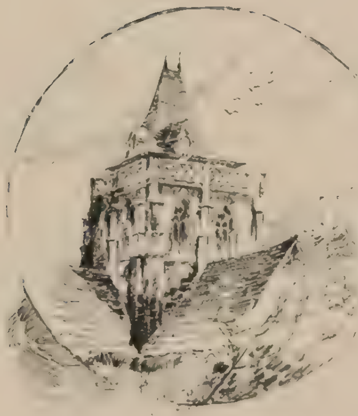
It is believed that the book will be found much improved in this edition, and even more acceptable than the preceding issues.

THE PUBLISHER.

CHAPTER I.

PRELIMINARY STEPS TO BUILDING.

SUGGESTIONS FOR BUILDING COMMITTEES.



THE following directions for the various steps to be taken in building a church are, with the exception of paragraphs IV., V. and VI., taken from the catalogue of the Board of Church Extension of the M. E. Church. They are so sensible and concise, and carry the authority of so extended an experience, that it is believed they cannot be improved. We earnestly recommend that all religious societies that contemplate building observe these directions in every particular.

I. *Organize according to the law of the State and the discipline of the church.* To make sure of this, act under the advice of an attorney familiar with both.

II. *Secure the best possible site on which to build.* Three things require attention:

1. That the site be central and convenient of access. Better pay full price for a lot in a central locality than to accept one as a gift at one side of the population.

2. That it be commodious, furnishing ample room for church, and, if practicable, for parsonage also.

3. That the title be perfect. In every case have the records examined, and the deed drawn by an attorney or conveyancer familiar with such business. The deed should be to the church, under its *corporate name*, and for Methodist churches should include the *trust clause* of the discipline, unless the laws of the State provide to the contrary.

III. *Provide the means to build without embarrassing debt.* If possible, secure three-fourths of the estimated cost by actual subscription. Put little faith in

indefinite promises, and do not depend upon aid from abroad except it be on application made to the Board of Church Extension. Aid obtained from the Board may be included in the estimated three-fourths of the entire cost, but nothing less than the official notice from the parent Board itself that a grant has been made should be accepted as a promise of aid. If possible, arrange your plans so that subscriptions to be taken at the dedication will cover any remaining indebtedness.

IV. *Secure suitable plans prepared by a competent and experienced architect.* In many small towns much ignorance often exists of the importance of having complete plans and specifications prepared by an experienced architect. The greatest diversity of opinion will be found on the matter of a suitable plan. Everybody will have a plan, each of the trustees will have a plan, the pastor will have one, the carpenter will have one. As a result, it is often decided that a plan is not needed, as the carpenter can build without one, and the outcome is an awkward, ill-proportioned, inconvenient structure, not likely to awaken devotional feelings in those who look at it, or who may enter it for worship. Further than this, such buildings generally cost more than those built from an architect's plan.

Every board of trustees should recognize that money is saved, and a much better building in every way is obtained, by having plans prepared that will exactly meet the requirements of the society, and the conditions of the site, climate and materials available for building.

The building societies and boards of church extension of many denominations furnish stock plans for churches, which, being reproduced in large numbers by mechanical means, are sold at a much lower price than it is possible for an architect to make them. While these plans are much better than none, they will generally be found not suited to local conditions, or to the lot, or the needs of the society, and the saving of a few dollars in the cost of the plans will be found to be more than offset by the resulting inconveniences and a large bill for "extras."

A special plan prepared especially to meet the needs of the society, and the conditions of the site and climate, will invariably be found to give better satisfaction.

V. As soon as it is definitely decided to build, a building committee of not more than five persons, thoroughly conversant with business affairs, and in full sympathy with the work of the church, should be chosen at a meeting properly called for the purpose, and given authority to select an architect. The amount of money that it is thought possible to raise should also be considered, that

the building committee may have some basis on which to proceed.

In selecting an architect the committee should endeavor to secure the services of one who is not only competent and experienced in his profession, but also in touch with the work of the church and familiar with the services and the working of the various branches. It is frequently thought advisable to institute a competition amongst several architects, for the purpose of selecting the best plan, but, except in the case of a cathedral or monumental church, more satisfactory results will almost invariably be obtained by deciding on some particular architect at the start, consulting with him as to the selection of a site and studying with him the various conditions of the problem. Any architect skilled in his profession should be able to design a good and substantial building, but unless he is acquainted with the services and the various lines of church work, he will not be likely to devise as desirable an arrangement as an architect who is familiar with all of the requirements.

The experience gained in building many churches is also of great assistance to an architect in providing for good acoustical results and a satisfactory method of heating and ventilation. An experienced church architect can also usually keep the cost lower than one without such experience.

Above all, an architect should not be selected because he offers his services cheaper than others. A capable architect will seldom compete in price, and an incapable architect will cost the society much more than the reduction in his fee, and will seldom give satisfaction.

When an architect has been chosen he should have the full confidence of the building committee, and his advice should be sought and carefully heeded on all matters.

VI. *Architect's Supervision.* It is very desirable that the erection of the building, whether large or small, shall be under the supervision of the architect who prepared the plans and specifications, and whenever the architect resides within a reasonable distance of the building the building committee should certainly arrange with him to supervise the carrying out of the plans and specifications, which will usually require at least three or four visits during each week, and at certain stages of the building daily visits are advisable. If the architect lives at such a distance that it is impractical for him to visit the work, except occasionally, some person who is familiar with plans and building operations should be employed to inspect the work daily, and the architect called upon to visit

the work at important stages. Many large churches have been satisfactorily erected in this way.

There are many places in the construction of a church where the builder may, through ignorance or carelessness, or a desire to increase his profits, endanger the safety of the building, to say nothing about injuring its appearance and durability; and such changes can generally be made without the knowledge of the building committee. The architect or an intelligent builder, however, cannot be deceived, and efficient supervision by him should be a guarantee that the plans and specifications have been faithfully followed. The money paid for such supervision is generally well spent.

VII. *When you have adopted your plan suffer no change to be made under any pretense whatever.* There will not be wanting those who do not know the alphabet of church building who can suggest *"improvements."* (?) Heed them not. In nineteen cases out of twenty, if you do, you will mar the building and increase the cost. Guard especially against any efforts on the part of builders to induce changes. They frequently desire, especially when building under contract, to open a door for *bills of extras.* Follow the plans strictly, and if any questions arise, consult with the architect, and proceed under instructions from him.

VIII. *Let every transaction be carefully recorded.* See that the trustees are provided with a suitable book, and that the proceedings of every meeting are accurately recorded. Let the building committee report to the trustees *in writing,* and have their reports entered. Keep careful account of every dollar received and expended, and preserve these accounts with the records of the trustees. Then at the dedication a complete report can be made to the public. This, being printed and scattered among the people on the eve of the dedication, would inspire confidence, and make the raising of the remainder needed comparatively easy.

Careful attention to these suggestions will secure, as a result, a church property the title to which will not be questioned, situated in the midst of the people for whose use it is intended, convenient and attractive—suited to the wants of church and Sunday school, and in no danger from the sheriff's hammer. The complete records of the business, and of all receipts and expenditures, will avoid danger of controversy over disputed questions, and the church will have an open way to a career of prosperity.

DESIGN AND GENERAL REQUIREMENTS.

DESIGN.—Although it is not the purpose of the author to give instructions as to the architectural or decorative treatment of church buildings, a few words in regard to ecclesiastical art may not be amiss.

In the first place, a church is supposed to be a temple, erected by man to the glory of God and for the observance of religious services and the spreading of His Word. The aim of the architect and of the church body should, therefore, be to express this purpose as clearly and distinctly as may lie in their ability, while at the same time providing suitable arrangements for the church services and conveniences for such charitable or social work as the church may undertake.

When erecting a habitation for the most high God, the church should not be niggardly in its expense, but should feel that nothing is too magnificent for an offering to the Lord. "The house that is builded to the Lord must be exceeding magnificent." I. Chron. xxii., 5.

The history of church architecture in this country shows an almost total lack of appreciation of the sentiments above expressed. It is true that we have many good examples of church buildings, but, compared with those that give no expression of reverence, holiness or inspiration, they are but few indeed.

In no instance is a keener sense of architectural propriety more needed than when designing a church. "The sin of unchristian building is not committed willfully, nor with joy that so much evil be perpetrated. The error lies not so much in doing of what ought not to be done, but in not knowing what should be done."*

To lay down the principles of Christian architecture and art, or to tell how to design a building to be dedicated to God, so that it will testify of reverence, faith, love and charity, is a most difficult if not impossible undertaking, and one that has been rarely if ever attempted.

*Barr-Ferree.

A few suggestions, however, may perhaps serve as helps along this line.

First.—The work should be entered upon in a spirit of reverence and love and with a desire to build pleasing in the sight of God. No shams or subterfuges of construction should be permitted. The building, above all, should be honest and truthful, even if it must be plain. If a demand exists for a certain room or adjunct of the church, it should be provided in a straightforward and simple manner.

The author believes that much help may be obtained by studying the traditional architecture of the church and the reasons or conditions that called it into being. When, however, the belief of the church or the character of the service is such that traditional forms have no significance, and the faiths they mutely express are not believed in, it would be architecturally, if not morally, wrong to use them. The amphitheatre church, for instance, is usually designed for an entirely different service than that of the Church of England, and requires a new and different treatment. Such opportunity as there is for dignity and reverential treatment, however, should be made the most of, and every effort made to express reverence and worship. It should be remembered that all churches still give assent to the Apostles' Creed, and that all are worshiping the same God, only in different ways. Because the form of service has been changed is no reason why the audience-room should resemble a theatre, or the minister's platform be fitted up "like a hotel parlor."

When the conditions admit of the honest use of forms which have the holy association of Christian use, they will have a strong influence in producing a religious feeling in the worshiper as mankind is greatly influenced by associations and traditions.

In regard to the architectural style of the church, that may be a matter of choice with the designer, although one style may perhaps be more appropriate for a particular location than another. Thus, for Texas and Southern California the Spanish Renaissance or the styles developed in Italy seem more appropriate than the Northern Gothic or Romanesque.

It is well to remember that there is nothing sacred in any one architectural element. All have been employed upon secular as well as upon sacred buildings. "It is feeling that makes a structure Christian—a feeling of reverence, love, faith and hope."

Although it is not style nor ornament that makes a structure Christian, but rather the manner in which the architectural features are used, still it appears to be easier to give a religious impression to a building by means of the Gothic than by either of the other styles. It is also a noticeable fact that the larger proportion of the best ex-

amples of church architecture, both in this country and in England, are in the Gothic style.

"The Gothic has the distinction that belongs to no other style, of having been developed under conditions essentially Christian. Its period was perhaps not more religious than our own in the strengthened intensity, and the diffusion of the Christian life, but it was an age in which religion filled the thoughts of the people in a fuller way than with us. The people of the Middle Ages had fewer things to think of, fewer things to do, fewer things to distract their attention. The culture of the time was centered in the church, and it led the people actively and aggressively as it never did before nor since.

"The architecture of this period, which we call Gothic, is, therefore, more especially Christian than any other. It was developed among Christian people, and its finest monuments—glorious structures testifying in every stone of reverence, faith, joy, love and charity—were churches dedicated to God's service.

"No other style has this distinction nor has any other style so accurately and beautifully expressed man's faith in his Creator."*

The Renaissance style has given us some beautiful examples of Christian art—one the mightiest in all the world—but it is not so easy to express the Christian principles in this style as in either the Gothic or Romanesque.

The Romanesque is more nearly related to the Gothic, and its best examples are found in buildings erected for the Church.

In regard to the interior of the church, and particularly of the audience-room, it should be the aim of the architect to create an interior that shall be at once sacred and holy, inspired, reverential, devout. Comfortable seats and the ability to hear and see the speaker are also considered essential in the modern church. By many they are considered the most essential requirements, but to the admirer of Christian art these are mere incidentials, the trimmings, as it were, of the structure whose art, given by the architect, must speak clearly and in no uncertain way, of the most precious possession of humanity. It is possible, however, to have a well-arranged and "practical" or useful church, and at the same time so designed as to express the feelings mentioned above.

In the Ritual or Liturgic Churches the decoration should be such as will give a proper and righteous background to the solemn celebration of the Church sacraments, processions and other sacred functions. Also the lecture hall, set apart exclusively for Christian worship, should illustrate the same Christian trust and faith as ap-

*Barr Ferree in the American Architect.

pears to be naturally expected of those religious bodies which retain the altar ceremonial. "It need not follow the traditional form of the church building, it need not seek to be other than what it is, but it must express its purpose as clearly and as distinctly as the Liturgic Church."

In conclusion, it must be admitted, perhaps, that God can be worshipped as truly in an amphitheatrical church as in a Gothic cathedral, but it is nevertheless true that a church which speaks unmistakably of its mission and inculcates in the attendant a feeling of reverence and faith in God adds greatly to the effect of the service, and may often touch the heart where words alone would fail.

Christian art and architecture, moreover, are not incompatible with a well-arranged and comfortable church.

FLOOR PLAN AND GENERAL ARRANGEMENT.

Modern religious development has divided the Christian Churches into two great classes, the liturgic and non-liturgic. In the latter the preaching service is the most important, and the church building becomes, practically, if not actually, a preaching hall. In the former group the ceremony at the altar is the essential service, which is conducted with more or less ceremony of physical worship.

The liturgic or ritualistic churches also differ more or less in the form of their service and the doctrine which they teach. Of the strictly ritualistic churches the Roman Catholic and the Anglican Church are the two great types in America. The Anglican, or Protestant Episcopal Church, as it is more often called, is also divided into "High" and "Low" churches, the term "Anglican" being more properly applicable to the "High" Church.

PROTESTANT EPISCOPAL CHURCHES.

The service and traditions of the Episcopal Church require certain arangements and divisions of the church building peculiar to this church, although one or more of them may be adopted by other churches. The more important of these requirements are space for the worshipers, a place for the clergy and choir, a sanctuary, or raised platform for the altar, and a robing-room for the choir and clergy.

Several plans adapted to the service of the Episcopal Church, and to churches of varying size and means, are shown by plates I. to XI.

The Protestant Episcopal Church of America, being the offspring of the Church of England, and using essentially the same prayer-book and ritual, has naturally turned to England for the type of their church building,

FIG. I. ST. JOHN'S CATHEDRAL. DENVER, COLO.

and the similarity of conditions in the smaller cities and villages makes it especially appropriate that they should do so.

Mr. R. Clipston Sturgis, in a paper on "Church Architecture," read before the thirty-first annual convention of the American Institute of Architects, speaks as follows of the English parish churches, embraced in the period from the twelfth to the sixteenth centuries:

"For the country they have proved themselves through many generations of use to be suitable, and no one can be familiar with the country churches of England without feeling their perfect charm, their churchly character and the spirit of worship which seems to pervade them. The most striking feature of these churches is that they are long, narrow and low. Among the thousands of churches built during these centuries there is hardly one but has these characteristics.

"Regarding the proportions, one might safely say that the average length of the chancel was double the width and that of the nave from three to four times its width. It is evident, therefore, that this shape was found satisfactory to these many succeeding generations of people to whom church going was a most vital part of everyday life.

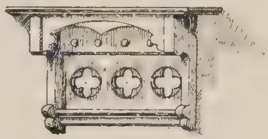
"There are many things to recommend this plan.

The narrowness gives value to the length, which, on a small scale, might otherwise be of no architectual importance, and the length gives dignity to what is the focal point of interest with all Catholic bodies, the altar, and with others the preacher's desk and chair. The long, narrow nave has proved satisfactory as an auditorium, for it is practically a speaking tube.

"For our modern use this plan is suited without change to all bodies which use a ritual, for to them it gives opportunity to emphasize the chancel and altar, to gain the dignity of at least one grand dimension in a small building, and yet, by placing the pulpit at the crossing or in the nave, make a perfect auditorium. A building 20x80 gives the architect a better chance for architectural expression, both inside and outside, than one 40x40.

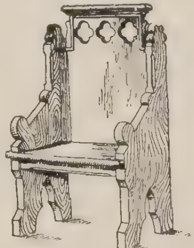
"The next distinctive feature of the mediæval churches is the division of the building into chancel, crossings, transepts, nave and aisles. Whatever may have been the origin of the cruciform, this one thing is certain, that for all these people it signified the cross which, except in the very earliest days, has always stood the foremost symbol of the faith.

"The aisles signified the Trinity. Besides these more obvious symbolisms, the chancel represented the Church triumphant, the nave the Church militant, or the new and old dispensation. The chancel was further divided into sanctuary and choir, the one for the celebration of the Holy Eucharist (partaking of the bread and wine), the other for the due rendering of the service. The sanctuary was fitted with altar, credence piscina and sedilia, and the choir, besides stalls for clergy and choir, had lectern and pulpit. The altar represented the real presence of the Lord's body; the choir, the need of orders and ritual.



A CREDENCE SHELF

Fig. 2.



BISHOP'S CHAIR.

Fig. 3.

"Such, in main, are the features of the old churches, which, as they answered needs similar to those of our liturgic churches, may be fitly followed to-day.* There are other needs which are the outcome of growth and the advance of civilization with which they were not called

*The illustrations on plates 9 and 10 show two good examples of English country churches, and plate 11 shows a design in the same spirit, adapted to American villages and suburbs.

Fig. 4. WROUGHT IRON ROOD SCREEN.

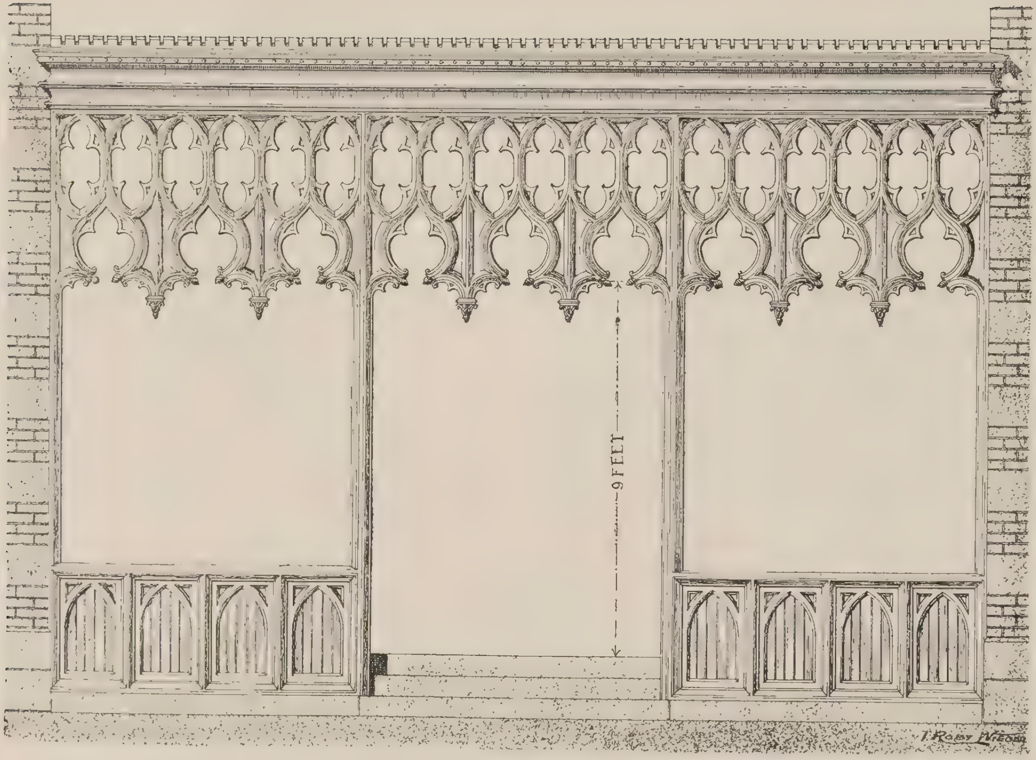


Fig. 5. ROOD SCREEN OF WOOD.

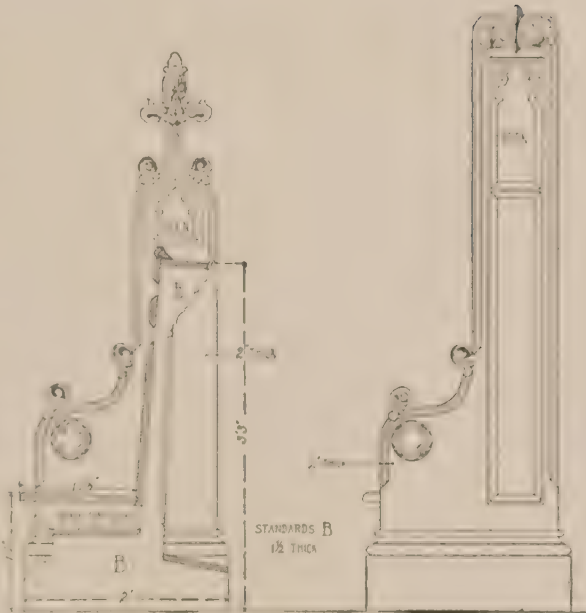
upon to grapple and which we must solve for ourselves."

The requirements of the Episcopal Church of to-day in the way of a church building may be set down as follows:

First, space for the worshipers, or people, choir and sanctuary. In connection with the choir a place should be provided for an organ. There must also be a robing-room for the clergy and choir if there is a surplice choir. These rooms or accommodations are necessary even in a very small church, although they may, of course, be smaller in small churches than in a large one. For a very small church, the plan shown on plate 1 is a very good arrangement. The tower, including the study, could be omitted, if necessary, to save expense, but it is desirable to have a small room for the use of the rector and for the meetings of the vestry.

To best meet the needs of the Episcopal Church of to-day, the Architect must be familiar with the service and thoroughly in sympathy with it, as well as with its Architectural expression.

The service of the chancel and sanctuary, so to speak, has been so admirably set forth by Mr. Sturgis in the Brickbuilder, for April, 1905, that the Author has taken the liberty of quoting him.

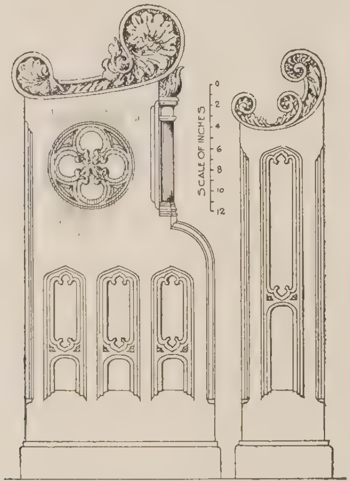


ENDS FOR CHOIR SEATS.

Fig. 6.

"The choir form in their vestry and lead into the church, followed by the clergy. The vestry for the choir should be, therefore, so located as to make it convenient

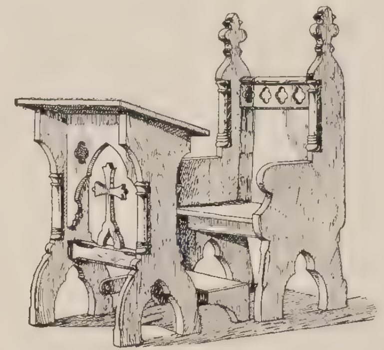
for clergy to join the choir, and at the same time the clergy vestry should be so convenient to the church as to make a direct entry possible when the choir is not used. This secondary entrance would serve also when



DETAIL OF STALL ENDS
Fig. 7.

the celebrant goes direct to the Altar and does not follow the choir on their entry.

"Besides choir and clergy vestry, there should be also the sacristy for vestments, Altar hangings, etc. In many churches these would be of simple description and would require little space, but where the colored vestments are used by the clergy, and where the Altar has fontals and superfontals and perhaps embroidered hang-



PRIE-DIEU BISHOP'S CHAIR
Fig. 8.

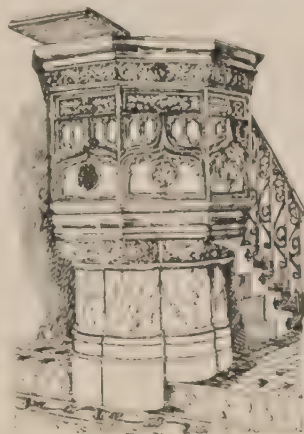
ings to serve as reredos, the proper care of these, which must not be folded, requires special consideration.

"There are various ways of bringing the choir into church; the simplest and most direct seems to me the best. Many think that a procession is a ceremony by it-

self, reserved for important occasions, for high festivals; others consider it a part of every service in which the choir joins. The entry into the chancel and arrangement of the choir stalls will to a certain extent depend upon the point of view.

"The people now demand an intimate share in the services of the Church which was not considered in the middle ages. For this reason a structural rood in a parish church is not only unnecessary but actually objectionable as cutting off the choir and more especially the Altar from view. The significance of the rood, however, remains, and the rood beam meets modern requirements and at the same time preserves the symbolic significance of the cross as the means of access to the Altar. With the rood beam one often finds a low barrier which serves to mark in dignified manner the separation between nave and choir and, in part, helps to screen the boys who, one regrets to say, are not always the edifying sight they should be.

"The pulpit, through its over-emphasis in Puritan days, has remained a very important factor in the church, and it is imperative that in a good modern church every one should be able to see or at least hear the preacher. It seems to be an accepted fact to-day that preaching has come to stay and must be recognized as an essential part of the service. With this in view much of the study of Architects has been on the question of how to retain the symbolic nave and aisles and yet make a fair auditorium within which all of the seats are good. The most practical and most modern solution is to reduce the



A PUL[illegible]

Fig. 9.

ALTAR·END·

Fig. 10.

aisles to a dimension where they serve practically nothing except passage ways."

Arrangement and Furnishings of Choir and Sanctuary.

The typical arrangement of choir and sanctuary for large Episcopal churches is admirably shown by Figs. 7 and 8, which are reproduced by permission of the publishers, Messrs. Small, Maynard & Co.,* from "Church Building," by Mr. Ralph Adams Cram, a most complete and valuable work on the Architecture and accessories of Protestant Episcopal Churches.*

The transition from the nave to the choir should be indicated either by a parapet of some kind or by a choir screen. In small churches a parapet or railing of plain panels, with a heavy rood beam above carrying a crucifix or cross, seems most appropriate. The rood screen seems to be most effective where the church is of great length and height.

Figs. 4 and 5 show examples of rood screens (sometimes called choir or chancel screens), and Fig. 6 is an excellent example of the use of the rood beam.

In many churches the parapet is made of stone or marble, but where economy must be considered a simple railing of wood is commonly used.

Elevation of the Choir, Sanctuary and Altar. This is a matter of importance in Episcopal and Roman Catholic churches, although there does not appear to be any fixed rule either of the church or tradition by which it may be determined; unless it be that the series of steps (risers) shall be an odd number. The more common custom in the smaller Episcopal churches appears to be to raise the choir floor three steps (i. e., risers) above the main floor, then the sanctuary one step and the altar three steps more, making the elevation of the Altar seven steps above the floor of the nave. In large churches it is customary to raise the kneeling space in front of the communion rail either three or five steps, as in Figs. 7 and 8. Then there snould always be one step at the communion rail and three to the foot pace of the Altar, making the total elevation of the Altar 10 or 12 steps above the floor of the nave.

The number of steps does not appear to have any special religious significance, although the numbers 3 and 7 have a peculiar significance in the Christian religion.

The chief object in elevating the Altar, Sanctuary and choir is to magnify the Altar and to afford a better view of the Altar services, as well as to make them more impressive.

Dimensions. The chancel of a church, designed for the Episcopal ritual, should be as large and dignified as

Of Cambridge, Mass.

the dimensions of the church will admit. A width of less than 24 ft. will give a cramped appearance, where there are choir stalls, and a width of from 28 to 32 ft. is to be preferred. At least eight feet between the front row of choir stalls should be provided in small churches, and in large churches 10 to 14 ft.

"Where length is possible, it is better to have only two rows of stalls on each side; for the deeper the chancel, the better it is in every way."*

Plan of Sanctuary. For the village churches, and city churches of moderate size, the sanctuary should be square, rather than polygonal. This latter form is dangerous and but seldom used to good effect, except in cathedrals or churches of great size.

Chancel Fitting and Furnishings. At each side of the choir are placed seats, usually designated as stalls, for the clergy, and in front of them benches for the choir. In large churches each row of stalls or choir benches should be raised one step above the row in front, these steps being carried across the choir beyond the seats. When the building fund will admit, the clergy stalls should be divided into separate seats, and covered by traceried canopies, those nearest the choir parapet on each side receiving greater richness of treatment. (These clergy stalls are used for the visiting clergy.)

*Ralph Adams Cram.

Where the chancel is small, separate seats are partitioned off from the choir benches, for the rector and curate as in the plan, Plate I., also plan A, Plate IV., and where there are no clergy stalls, very often separate seats, similar to that shown in Fig. 3, are placed at the front end of the choir stalls for the rector and assistant. When such seats are used a short prayer desk, called the "Prie Dieu" (Fig. 8), should be placed in front of them.

Traditionally, the pulpit should be a little in front of the choir, outside of the rail or screen, and on the left side of the church as one faces the Altar. The reading desk or lectern should be on the right side just inside the rail.*

In modern churches the position of the Altar and lectern is often reversed and the pulpit placed near one of the piers supporting the crossing or wherever the best acoustical effects are produced. In large churches it is generally elevated several steps, (see Figs. 9 and 102) and even in small churches it is well to elevate it one step. The book rest should be made so that it can be raised or lowered.

*Most if not all of the early churches were placed so that the nave extended North and South the chancel being at the East end of the church. With this arrangement the Pulpit and Bishop's chair were on the North side of the chancel and the credence and also the sedilia, or seats for the priests on the South side. The North side was considered as the "Gospel Side."

"Where there is no vested choir, the lectern may very well stand in the center of the chancel, before the Altar, in the old monastic way."

R. A. Cram, in "Church Building."

Occasionally a litany desk is used. This should be placed on the floor of the nave, in the central aisle, just in front of the choir, and should face the Altar.

The Communion Rail separates the sanctuary from the choir. For the comfort of communicants the rail, if five or six inches wide, should not be more than 24 in. above the floor; if a brass rail is used it may well be elevated 26 in. above the floor. The communion rail should be comparatively light and supported by standards about 3 ft. apart. There must be an opening at least 3 ft. wide in the center, and in order to accommodate as many communicants as possible, some provision should be made for closing the opening during communion. Where a brass rail is used, it is common to close the opening by tubes which slide inside of the rail, telescope fashion. With wooden rails, a section of rail may be arranged to fold back on a hinge. A step 12 in. wide and 6 in. high just in front of the rail is absolutely essential.

The Sanctuary should contain the Altar, the seats, or sedilia for the bishop and the priests, and the credence.

The Altar is always placed on the center line of the chancel and generally against the end, or east wall. It should be from 3 ft. 4 in. to 3ft. 8 in. high, from 24 to 30 in. wide and from 6 to 10 ft. long, 6 ft. being a good length for small churches.*

At the back of the Altar should be a raised shelf, called the retable, about 12 in. wide.

The Altar should be the culminating point of the church interior, and may be as rich and elaborate as the money will allow—it may be of wood, marble or mosaic, but never of metal. When there is ample means, a reredos, which more commonly takes the form of a sculptured screen, is desirable as a proper background for the Altar. But unless there is both the means and the ability to design a reredos that is absolutely right in design and richness, it is far better to rely on some form of dosel, or simple hangings. A reredos that is not rich and splendid is out of place, and has no excuse for its existence, while a dosel may be provided for a comparatively small sum.

"The dosel that consists of a flat curtain of vertical strips of alternating brocade and some plain and rich material, a projecting canopy or 'lambrequin' and wings of a stuff somewhat lighter in weight, is by far the best form.

*One authority says: "Even in very small churches, the Altar should be large, 8 ft. in length being about the minimum, though side Altars may be shorter."

A dosel that hangs in folds has too much the effect of upholstery, and it lacks the dignity so requisite."*

The Bishops chair should be on the north or Gospel side of the sanctuary. In small churches it may be a simple, substantial chair, on the order of those shown in Figs. 3 and 8. Where the money is sufficient for something more elaborate, the Bishop's chair should be distinguished by the Episcopal insignia of the Mitre, the crossed keys and the crosier, and where the rest of the chancel is fitted up to correspond, the seat should be covered with a canopy of rich carving. Where there is an elaborate ritual, the Bishop's chair should be divided into three sections, either by a chair and two flanking stools placed in a canopied recess, or like stalls, by arms and ornamental partitions. A kneeling bench should be placed before the middle section only. On the south side of the sanctuary should be the sedilia for the priests. This should properly be divided into three seats, for the priest, deacon and sub-deacon, but in small churches there are often but two seats. The priest's sedilia should be similar to that of the Bishop, but less elaborate.

The credence (which is a kind of shelf) should be large enough to take the vessels containing the elements, and also two candles. It should be either on the south or east wall. The best arrangement for the credence is a niche in the wall, with the bottom projecting a few inches. In inexpensive churches the credence is usually a simple shelf similar to that shown in Fig. 2.

The ceremony of baptism requires a stone or marble font, which in modern churches is generally placed in the body of the church, near the choir rail. That the people may see the ceremony, it is desirable that the font set on a raised platform, as in plan F, plate III.

In ancient churches the font was usually placed close to a pillar near an entrance, or in large buildings in the middle of the nave, opposite the entrance porch. Very often an alcove or small room is built at one side of the church, near an entrance, to contain the font.

In the Low Church the choir often consists of a mixed quartette without surplice, in which case they may be placed outside the chancel, or in a gallery at the front of the church, as in Trinity Church, Boston.

Some clergymen prefer to have the altar raised still higher than this, and then the chancel floor may be raised three steps above the choir floor, and the altar three steps above that, making the total elevation nine steps.

Such, in the main, are the actual requirements of the service of the Episcopal Church. Besides these, it is often desirable to have a small chapel, a working sacristy, and rooms for the Sunday School, the various guilds, etc.

When possible, it is best to provide for Sunday

*Ralph Adams Cram.

School and guild room in a separate or detached building, or Parish House. If this is not possible, these rooms may be in a high basement (called in Ecclesiology the crypt). The smaller churches usually hold the Sunday School in the nave using the pews or benches for seats. A few churches have a large vestry built on to one side of the church, but this arrangement is hardly consistent with what some would call true church Architecture, and certainly is without precedent.

Working Sacristy. The need of adequate sacristy accommodations, and the true purpose of the various sacristys has been so well set forth by Mr. Cram in his "Church Building" that the Author has taken the liberty of quoting in part from his description, hoping that the quotation may be an incentive to those who are interested to procure for themselves a copy of this most valuable book.

"One mistake that is frequently made in the building of churches is that of failing to provide adequate sacristy accommodations. Even in large churches we frequently find only a priest's sacristy and a choir vestry. This is quite inadequate. A working sacristy is imperative. The priest's sacristy should be neither an anteroom nor a study, it is for the vesting of the clergy and for this only. The choir vestry should be used as such only.

"An Altar or working sacristy is absolutely necessary. This is the room for the altar guild, if there is one, and for the acolytes, if the usage of the church calls for them. It is also for the sacristan. Indeed, it is a kind of central office of administration; and without it a church is seriously hampered. Here the flowers are prepared for the Altar, the Altar vestments stored and made ready for use, Altar ornaments cleaned and taken care of.

"This room may also be used for vestry meetings by the wardens. A large chest or case in the center will hold frontals and superfrontals. There should be a sink and tables for the preparing of flowers, cases or racks for banners and processional crosses, storage for candles and incense—if they are used—presses for the vestments of the acolytes, a brazier for kindling charcoal, a large safe or vault for the storing of the more valuable ornaments, the books of the parish, etc., indeed provision for the thousand and one things that go toward making up the modern service in its richest form. If possible, the working sacristy should be located between the priest's and the choir sacristy, and it should be so placed as to give immediate access to the chancel." A working sacristy is shown on the Plate XLIX. Of course the actual needs of any particular church, in the way of vestry room and sacristy will depend very largely upon the character of the service, and can best be learned from the rector.

Chapels. Most of the established churches of England and Europe have at least one chapel, and many of the larger churches, and even some of the comparatively small ones, have several. In many cases, these chapels were added after the original building was built, the money for their erection being given or bequeathed by some individual. In this country, most of the finer Episcopal Churches, erected within the past thirty years, have at least one chapel, and from an Architectural standpoint, they add greatly to the interior effect.

Where there is but one chapel, it is used principally for daily and early Sunday Morning service, and should therefore be easy of access, and convenient to the priest's vestry. The most common location when there is but one chapel, is on the south side of the Altar.

The chapel requires no choir, and the sanctuary may be quite small, as it usually contains only the Altar and credence. Just outside the communion rail, there should be two stalls or seats, one on either side, and also the lectern, although if the chapel is large, the stalls are often placed inside the communion rail.

ROMAN CATHOLIC CHURCHES.

Th service of the Roman Catholic church being quite similar to that of the Episcopal church, the building requirements are or should be almost identical.

Those features which are especially marked in the typical Roman Catholic church of America, are the three Altars, the confessional and the location of the choir.

All Catholic churches have a chancel, raised above the floor of the nave as in the Episcopal church, and nearly all of the larger churches have side altars, one being dedicated to the patron saint and the other to the Virgin Mary. The choir, however, is not commonly vested and instead of being in the chancel, is usually placed in a gallery at the front of the church, where the organ is also commonly located.

The sanctuary, therefore, in Catholic churches, usually occupies the larger part of the chancel, and the communion rail is either at the very front of the chancel or projects a few feet into the nave.

The font is commonly placed near the chancel, although there is a great variation in this respect.

The confessionals are sometimes in one of the transepts or in the side aisles. In the church shown on Plate XLVI., they are in alcoves built into the side walls. The more pretentious churches usually have a clerestory with columns dividing the body of the church into nave and aisles and a transept on either side.

Several floor plans of Catholic churches are shown by Plates XLVI to XLVIII and Plate XLVI shows a typical interior with chancel and side altars.

Fig. 11. INTERIOR ST. ELIZABETH'S CATHOLIC CHURCH, DENVER, COLO.
F. W. Paroth, Architect.

Altars. The sanctuary of Catholic churches usually contains besides the altar, three seats for the priest and his assistants which are always on the right side of the altar.

When the bishop attends the service a temporary throne, consisting of a seat provided with a canopy is placed on the left, or North side of the sanctuary as in Episcopal Churches, and in a cathedral or Bishop's Church, a permanent throne is provided.

Two sacristies are required, one for the priests, and the other for the boys who assist at the service.

Stations. Catholic Churches usually have pictures or relief work, representing events in the journey of our Lord to the Cross, placed on the side walls, which are called stations. They are always 14 in number. The interior view, Fig. 11 shows two stations on each side.

NON-RITUAL CHURCHES.

The requirements of the non-ritualistic churches regarding the accommodations of their service and work, although large in number and varied in character, are at the same time simple as far as individual features are concerned, and there is no ecclesiological law or custom to govern one in his arrangements. There are also various ways in which the requirements may be met, according to the character of the site, the size of the building and the preference of the church body. It is, therefore, possible to give only a general statement of the requirements, and to show some of the ways in which they have been met, with a suggestion here and there as to the relative advantages and disadvantages of the different arrangements. It will perhaps be best to first enumerate the requirements of a working church of, say, three or four hundred members.

Requirements for the Preaching Service.

A. An audience-room that will seat the largest congregation that may be expected at any ordinary service.

B. An arrangement by which the capacity of the audience-room may be increased at special services.

C. Ample means of ingress and exit, vestibules, etc.

D. Pulpit platform, space for organ and choir.

E. Rooms for pastor and choir.

The Methodist and Lutheran churches also require an altar rail in front of the pulpit for the celebration of the Communion service.

Baptist churches require a baptistry for immersion, and two or more dressing-rooms.

Requirements of Sunday School, Societies and Social Work.

a. Ample accommodations for the Sunday school, with one or more class-rooms.

b. Lecture-room for prayer and weekday meetings.

c. Room for the school library.

d. Parlors for ladies' meetings and sociables, in connection with which should be a well-equipped kitchen and serving-room.

e. Rooms for the church societies, such as the Christian Endeavor, Epworth League, King's Sons, King's Daughters, etc.

f. Reading-room.

g. Church office.

h. Toilet-room, bicycle-room, room for heating apparatus, coal, etc.

How to meet all of these requirements in the best manner with the means available, and considering the size or topography of the lot, is a problem that must be left largely to the architect, although he should work in sympathy with the Building Committee and be well informed regarding the life and work of the church, and the line of work they propose to do, to be able to determine what arrangement will best suit the needs of that particular church and their work, and what accommodations are most needed and what perhaps can be dispensed with.

When the means of the church are limited, one room may be made to serve several purposes, and even in large churches this can often be done as well as not. Thus the main Sunday school room is generally used for prayer meetings, small midweek gatherings and social meetings. The church parlor is generally used for the ladies' meetings, committee meetings and social gatherings. The weekday reading-room may also be so located that it can be used on Sunday for one of the large Sunday-school classes.

The manner in which the rooms can be best arranged will depend upon the size of the lot, and whether it is a corner or inside lot, and also whether it is level or on a side hill. For economy it is often necessary to place some rooms above the others, and, in fact, almost the first question to be decided in connection with a large church will be whether it shall be a one or a two-story church.

One-Story Churches. When there is ample means and ground space to have all the principal rooms on the ground floor, this arrangement is undoubtedly the best for several reasons, the most important of which are: Greater ease of access, less peril in case of fire, and ability to throw several apartments into one; it is also much easier to secure good ventilation at a moderate expense when the rooms are all on the same level.

The one-story church also possesses the advantage that the plan may be so arranged that the lecture-room or Sunday school portion may be built first, and the audience-room at a subsequent period, without material waste.

INTERIOR, BAPTIST TEMPLE, BROOKLYN, N. Y.
Fig. 11A. G. W. KRAMER, ARCHITECT.

The designs shown on plates 17, 21 and 26 were made with this in view.

For small churches the building is almost always one story, with only the heating apparatus in the basement.

Two-Story Churches. In many churches the floor area required to accommodate the Sunday school, auxiliary societies and social features is greater than that needed to accommodate the preaching service, and in such cases it is generally necessary, on account of economy, to locate a number of the rooms in the basement and place the audience-room and possibly the main Sunday school room above.

When the basement is entirely above ground the building is called a two-story church; when the basement floor is some four feet or more below grade it is a one-story church with basement.

In the full two-story church the second story usually contains only the audience-room, with the necessary appurtenances, and perhaps the pastor's study and choir-room, all other rooms being in the first story, except the room for the heating apparatus, which is generally in a cellar.

With the same floor space, a two-story building can almost always be built for less money than a one-story building, as there is a great saving in the roof and foundations, and where land is expensive the saving in the cost of the lot is often a very considerable item.

The two-story building is perhaps best adapted to city churches, where the land is very valuable. It is, or has been, quite popular with the Methodist and Baptist de-

nominations, and, in fact, nearly every large city contains several examples of two-story churches, although one seldom sees a two-story Episcopal church.

When the lot is on a hill-side, grading downward from the principal street, a two-story church can be built to very good advantage, as the audience-room can be gained from the front entrance with but few steps, while a side entrance may enter directly on a level with the first floor.

It is easier to heat a two-story church, especially by hot air, than a one-story church containing the same floor area, but it is not so easy to ventilate the first story.

A compromise may often be made between the regular one-story and the two-story churches by locating the floor of the audience-room about six feet above the grade and placing the main Sunday School room on the same level and providing for the primary and junior departments in the basement, and also the kitchen and toilet rooms. If the basement has plenty of sunlight and can be kept from being damp this makes a very practical and economical arrangement. The church shown on plate XXIII was built on this plan, and has proved a most satisfactory arrangement.

The numerous plans of churches shown in the plates illustrate a great variety of arrangement both for one and two-story churches, of varying size and cost and adapted to different requirements. They should afford the Architect and Building Committee many valuable suggestions in meeting their own special requirements.

Practical Suggestions Regarding Arrangement of Rooms and Their Equipment.

The Audience Room, or Church Proper. As the principal service of the modern non-ritual church consists mainly of a sermon and prayers by a preacher, interspersed with songs of praise, either by a choir or by the choir and congregation in unison, it is evident that the sort of room or building best adapted to such a service is one in which the people can easily hear all that is said and sung, and in which the speaker shall be so located as to be within the closest touch with those he would instruct and lead.

If the size of the congregation was nearly constant from week to week, this would be the principal consideration (aside from the Architectural treatment), but as a matter of fact the requirements of a church auditorium as to capacity vary greatly at different times, not only with the condition of the weather; but frequently during the year special services are held which will attract an audience two or three times as great as the usual congregation.

Fig. 12. VIEW FROM THE GALLERY, ST. MATTHEWS ENGLISH LUTHERAN CHURCH, BROOKLYN, N. Y.
Showing Chancel, Organ, etc., and large Sliding Doors on the left. L. B. VALK & SON, ARCHITECTS.

A room which would accomomdate these special audiences on the main floor would generally be from two to three times as large as needed for the usual audience, and the appearance of a room in which not more than one-third or one-half of the seats are occupied is very depressing, both to the preacher and to the congregation.

Moreover, the cost of heating and maintenance is much greater for a large room than for a small one. Some arrangement, therefore, by which the room may be made of a reasonable size for the usual attendance and whereby its capacity may be increased to accommodate special services is most desirable.

There are two methods by which this may be attained. One is by the use of a gallery. The size of the room may be made such that seats on the main floor will comfortably meet the requirements of the largest fair weather attendance at the usual services, and then a large gallery provided, which need be used only on special occasions.

To secure proper proportions in a church seating three hundred people or more, requires considerable height, so that there is usually ample space for a gallery, and, if well proportioned, a gallery will help the acoustic properties and not interfere with the heating or ventilation. The effect of an empty gallery is also not as depressing as a small and scattered congregation on the main floor.

The other method of increasing the size of the audience room is by having a large opening between the audience room and the Sunday School room or lecture room, which can be readily opened or closed, as occasion may demand. This arrangement is sometimes called the "combination" arrangement, and is now very largely employed in non-liturgic churches, in some instances being carried to such an extent that the audience room may be increased to two or three times its usual size, and at the same time have the appearance of one large room. (See Fig. 13.)

This arrangement, of course, can only be used in churches that have the main Sunday School room on a level with the audience room.

Galleries can also be used, if desired, with the combination arrangement, thereby making the capacity of the audience room still more elastic.

In regard to the shape of the audience room, that best adapted to all the requirements of the average non-liturgic church, and especially for city churches, is a rectangle, whose depth, measured from the pulpit, is from five-eighths to three-fourths of the width. A square room, with the corners cut off, or an octagonal room, is also very satisfactory if of good size. A room from 40 to 50 ft. square, with the pulpit in one corner and the opposite corner cut off for stairs or vestibule, makes a very

INTERIOR UNION M. E. CHURCH, NEW YORK.
Fig. 13. G. W. KRAMER, ARCHITECT.

good room for hearing and seeing, but is difficult to treat successfully architecturally.

The long rectangular room, with the pulpit at one end, will give the greatest seating capacity for the floor space, and if there is a gallery opposite the pulpit, and the height of the room is properly proportioned, the acoustics will not be bad, but it is usually much better to place the pulpit on the long side and arrange the seating in concentric circles. This brings the congregation closer to the speaker, and overcomes the objection of a long vacant space between the preacher and his hearers when there is but a small attendance.

As a general rule, the nearer the main body of the seats can be contained within a sector of ninety degrees, measured from the speaker, the more satisfactory will be the arrangement.

Theoretically, the best shape for an audience room, considered from the acoustical standpoint, is the egg oval, but for various practical reasons, particularly that of expense, it is seldom attempted. An example of such a room, however, may be seen in the plan of the First M. E. Church, at Baltimore, Md., illustrated by Plate XXXI.

The effect of the shape of the room on the acoustics is further considered in Chapter VI.

All of the plans shown in this book give well-arranged audience rooms, although some must necessarily be better than others, as, on account of limitations of ground space, it is not always possible to obtain just the proportion of room one would desire.

Gallery. Wherever a seating capacity of more than

four hundred is required it will generally be advantageous to introduce a gallery at the back and sides of the church contiguous to the outer walls. The floor of the gallery should be arranged in terraces or steps at least

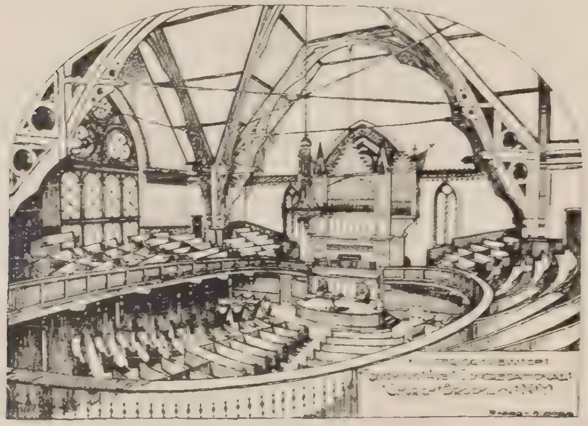


Fig. 14. L. VALK & SON, ARCHITECTS.

2 ft. 8 ins. wide, if pews are to be used, and not less than 2 ft. 6 ins. for assembly chairs, and with a rise of from 7 to 14 ins., as the sighting may require. A greater rise than 14 ins. is not desirable in a church, and the height and width of the gallery should be proportioned so that a greater rise will not be necessary.

As a rule, the front of the gallery should be as low as possible without becoming oppressive to those seated under; many galleries have been rendered almost useless by keeping them too high. Where there is a choir gallery a very advantageous arrangement is obtained by connecting it with the main gallery at each side of the pulpit by proper easements, thus making a continuous gallery encircling the room. Such a gallery is shown in Figs. 13 and 14.

Pulpit Platform. The pulpit platform is usually elevated 30 ins. above the main floor. It should be at least 5 ft. deep back of the pulpit [7 ft. 6 ins. over all makes a very satisfactory depth], and should be wide enough to contain at least six chairs. In the Methodist Church and sometimes in Lutheran Churches a communion rail is placed from 5 to 5½ ft. in front of the pulpit platform, the space inclosed being raised one step, and the step extending 10½ ins. beyond the rail, to kneel on.

Choir. The choir is usually placed either directly back of the pulpit platform or at one side, the location depending somewhat upon the size of the lot. In a large church it is probably best to place the choir back of the pulpit and to elevate it considerably. If back of the pul-

pit it should be elevated at least 18 ins., and if there is plenty of height and only a small choir to be provided for it may be elevated 8 or 9 ft. above the pulpit platform and brought out over it, as in the churches, Plates XXXVI., XLII., and LI. If provision is to be made for

Fig. 15.

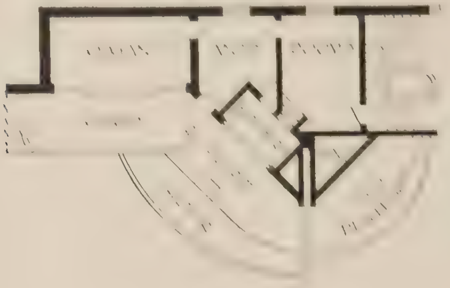
a large choir, say 20 voices or more, the choir seats should be arranged in concentric circles and the seats elevated in terraces as they go back from the center. The plans shown on Plate XXVIII and the interior view Plate XLVI, show a good arrangement for chorus choirs.

If the choir is at one side of the pulpit it is generally best to give it the same elevation as the pulpit platform. The arrangement shown on the plan Plate XXIII has been found very satisfactory, and for concerts, etc., it is very convenient, as the two platforms may be used as one.

Location of Organ. The organ may be placed either back of or at one side of the choir, or it may be divided so as to be on each side of the choir. The space required for the organ is considered in Chapter IV.

Baptistry. Baptist churches require a baptistry or tank that will permit of baptism by immersion, and baptistries are often introduced into churches of other denominations. The baptistry should be at least 42 ins. in depth, and from 4 to 5 ft. wide and 6 to 8 ft. long at the bottom. The depth of water required is usually about 40 ins. There should be steps or an incline, with cleats, leading down into the water. The best location for the baptistry is generally considered to be at the back of the pulpit platform and under the choir gallery. Sometimes it is placed at one side of the pulpit platform, as in the Baptist Church at Colorado Springs, Plate XXVII. It should be placed where the ceremony may be seen by the congregation and where it will not be conspicuous when not in use.

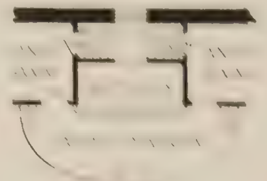
Mr. Geo. W. Kramer says on this subject: "The best arrangement is one whereby the candidate enters and emerges out of sight of the audience, generally back of the platform. The opening of the baptistry, back of the pulpit, should be closed with sliding doors, and curtains should be hung at the back in front of the steps, coming to within an inch or so of the water line, the candidates



being only seen as they enter already in the water. The arrangement shown by Fig. 16 is an ideal one for small churches, the ceremony being visible from the choir and auditorium." Fig. 17 shows a good arrangement where space is limited.

For a large church the arrangement of the baptistry in the Baptist Temple, Brooklyn, Plate XLV., and the Ninth St. Christian Church, Washington, D. C., Plate XLIV., is considered to be as good as can be devised. Fig. 18 shows a plan and section, to a larger scale, of a similar arrangement in another church by Messrs. L. [illegible] & Son. With this arrangement the candidates enter at one side and pass out at the other, the [illegible] until all of the candidates have been immersed.

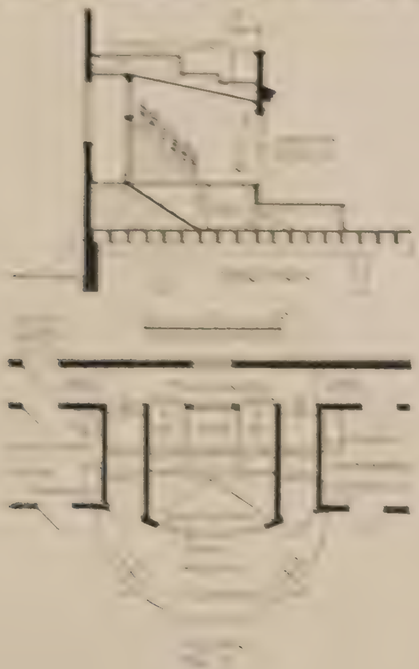
Back of the baptistry is a space for plants, [illegible] stained glass window behind. "In the Baptist Temple, the space back of the baptistry is modeled in perspective



and represents a mountain stream, with trees and plants at sides. The water is turned on at the top, runs over imitation rocks, cascades, etc., apparently for a long distance, finally falling into the baptistry at the back. The effect is further enhanced by electric lights placed back of the arches and also under the cascades. With the

proper use of colored lights and management of all accessories, the effect is very impressive."

The construction of the tank is described in Chapter X.



Stairways and Vestibules. The entrances to a church should be commodious and sufficient in number that the audience may pass out quickly. At least two public entrances should be provided for churches containing over 300 sittings, and if the building is on a corner lot it is desirable to have three public entrances, two of which should be located so as to admit the people at the rear of the audience room.

Ample entrances to the Sunday School rooms should also be provided, and such rooms as the church office, public reading room and pastor's study should have direct entrances from the exterior, if they can be conveniently arranged.

The public entrances should lead into a vestibule, which should be of ample size for the capacity of the church. A vestibule from 6 to 10 ft. wide, across nearly the whole front of the church, is very desirable, when the size of the building will permit. With such an arrangement a gallery usually extends over the vestibule to the outside wall.

Stairways should be placed in the vestibules, where required, and doors should be provided to control the galleries and all of the rooms separately. The outside vestibule doors are usually required by state law to open outwards.

The inner vestibule doors should be arranged in

pairs, not less than 5 ft. wide for the main entrances. They should not be too heavy and should be hung on double-action spring hinges. It is also desirable in large churches, although not absolutely necessary, to provide inner stairways connecting the galleries with the body of the church, so that the various services may be administered without passing out of the audience room.

The stairs leading to the audience room and the public stairs to the gallery should not be less than 4 ft. wide for the exit of fifty people, and 6 ins. should be added to the width for every additional one hundred people.

Ordinary "winders" should never be permitted. If square landings cannot be provided, the stairs should be built circular, the inner end of the tread to be 6 ins. wide. In no case should the risers of public stairs exceed 7½ ins., nor the treads be less than 10 ins. wide, exclusive of nosings. Not less than three risers should be introduced between landings.

Access to Attic. When there is an attic or space between the ceiling and roof, provision should always be made for entering it, and, whenever practicable, a comfortable flight of permanent steps or stairs leading to the attic should be provided, as the attic is often useful for storing lumber and miscellaneous things that may be used occasionally in decorating the church or in arranging a temporary stage for concerts, etc.

The attic also usually contains gas pipes or electric wires, which should be accessible. When no way of reaching the roof space from the inside can be arranged, then a scuttle should be placed in the roof to give access from the outside.

Pastor's Room. A small room for the use of the pastor, to prepare himself for the service before entering the pulpit, is quite necessary in every church. Many pastors do not care for a "study" at the church, in which case the pastor's room may be quite small. If a study is deemed desirable, it may also serve as the pastor's anteroom. The anteroom should be convenient to the pulpit and accessible either from a vestibule or directly from the exterior. If a study is provided, it should be so situated as to receive sunlight during a portion of the day at least, and should have direct communication with the exterior. If means will permit, it is desirable to have a fireplace in the study and a toilet room adjacent to it. It must, of course, be well lighted.

Choir Room. It is desirable to provide a room for the use of the choir, in which they may remove their outer garments, and through which they may pass to their seats. A closet or cabinet should be provided to receive the music.

Parlors. At least one room should be provided in every church which may be used during the week for

meetings of the Ladies' Societies, Special Committees or other official bodies. If the church is a small one, one room many be utilized for all of these purposes, and is usually designated as the Church Parlor. The size of the room should be governed by the number of persons likely to occupy it at any one time. In large churches it is well to have double parlors, which may either serve as two rooms or be thrown into one. If the parlor is placed on the same floor as the Sunday School, it may be arranged so as to be used as a class room during the school hour. The parlor should, if possible, be located so that the sunshine will enter it during the afternoon, as it is at that time that the room is most likely to be used by the ladies. It should be reached directly from one of the main vestibules.

When the funds of the church will admit, it is desirable to have a parlor fitted up especially for the use of the ladies, and another room that may be used as a *Church Office*. This room should contain from 150 to 200 square feet, so that it may be used for meetings of the official body of the church, and may be used as an office by the Pastor or Church Clerk. This room should be entered directly from the exterior, and should have a stove or fireplace, so that it may be warmed without running the central heating plant.

Kitchen. Much more is now made of the social element in church life than in former years, and most of the denominations now have frequent sociables and entertainments at the church, at which refreshments are served, and it is not uncommon to serve quite a dinner or banquet at one or more times during the year. In fact, in the modern, progressive church a well-equipped kitchen is almost indispensable for the social work. It should be fitted up with sink, range, hot and cold water, dish closets, etc., and be large enough to permit four or five ladies to work in the room at the same time. It should be located in a convenient place for serving the refreshments, and if the arrangement of the room will permit, a serving room, with double-acting doors and a large serving window connecting with the kitchen, will be found very convenient. The arrangement of the kitchen, serving room and dining room in the plan shown on Plate XXIII. has been found very convenient and a great help in carrying on the work of the church.

Generally one of the Sunday School rooms is used as a dining room, and the kitchen is placed adjacent to it. When, however, the social or dining room is on the ground floor and the kitchen in the basement, a dumb-waiter may be used in serving from one story to the other.

Reading Room. Many churches now maintain a reading room for the benefit of the young men and women of the neighborhood, which is kept open during the week. Where there is no public reading room convenient a church reading room is a great help in keeping the young people away from harmful influences, and if the books are well selected, a means of directing, to a certain degree, their line of reading.

Generally a room 16x20 or 24 ft. will answer for this purpose, and on Sunday it may be utilized for one of the departments of the Sunday School. An entrance to the reading room should be arranged either directly from the exterior or from a vestibule, so that it will not be necessary to pass through any other portion of the church to enter it. Unless the main heating apparatus is to be run continually during the cold weather, provision should be made so that the reading room may be independently heated, and an open fireplace will be found a very attractive feature in such a room.

Toilet Rooms. In city churches toilet rooms are an absolute necessity, and they are desirable in any church. It will be found that they are especially needed for the Sunday School. In locating the toilet rooms danger from freezing and avoidance of noise should be considered, as well as convenience.

Storage Closet. The Architect should endeavor to arrange for one or more closets for storing supplies, surplus seats, tables, decorations, etc., as some place for such things is always needed. Often the loft or attic may be made accessible for this purpose.

Bicycle Room. In many churches a room in which bicycles may be left during the service, and especially in the evenings, will be found a great convenience and probably lead to a greater attendance on the services.

Fuel and Heating Room. Provision must, of course, be made for the heating apparatus and fuel, which must be in the basement or cellar, unless stoves are used for warming. The room should be located where it is convenient for putting in the fuel, and the heating apparatus, if of steam or hot water, should be near the coal bins. If furnaces are used they should be placed where they will be most effective, even if it is necessary to carry the coal to them.

The above are the principal requirements in the way of rooms for the modern church, with the exception of the Sunday School rooms, which will be considered in the following chapter.

Very large "institutional churches" will probably need still more rooms, such as rooms specially fitted for the young people's societies, or perhaps a room for a day

kindergarten or a gymnasium. These requirements are so varied, however, that no special directions can be given for their arrangement. They must be studied for each particular church, keeping in mind the purpose for which they are to be used and the convenience and expense of conducting them.

SMALL CONVENIENCES THAT ARE GREAT COMFORTS.

[From *The Evangelist.*]

"We know of a man who lost his leg as the result of an irritating sore induced by a small nail in the heel of his shoe, and we have known all the occupants of a well filled pew to be so annoyed as to be out of all sympathy with the service by the presence of wet top-coats, muddy overshoes and dripping umbrellas. Many annoyances, which are none the less so qn account of their petty character, may be avoided by a little forethought in the equipment of churches.

"It is well to have within easy access of those entering the church a depository for outer garments or protections whenever such are made necessary by stress of weather. A small room for such use is provided in some churches, in which shelves, hooks, racks, etc., furnish conveniences for placing topcoats, overshoes, umbrellas, etc., in such a way as to be easily returned to their owners as called for, checks being given to all those leaving them. The room may be, indeed, should be, securely locked after the opening of services. This not only contributes very much to the comfort of those relieved of the annoyance of wet or cumbersome articles in their pews, but avoids any disagreeable odors or dampness arising therefrom in the warm air of the room, a sanitary precaution of no little importance.

"Many of our sextons complain of lack of small conveniences for their work. Some active churches are open nearly every afternoon and evening of the week for meetings of the congregation or the various auxiliary organizations for church work, and books, papers, letters and materials of various kinds are sent to the sexton for use at these gatherings. Few chuches provide any suitable place for the use of the sexton in properly caring for such things. For such use the depository should be amply large, be properly and securely fitted up, to the end that nothing be damaged by piling one package upon another, and that articles once put in place might not be disturbed by curious persons.

"Letters and packages to be delivered by mail, ex-

press or otherwise are often addressed only to the church, and in default of any place of deposit they are, or should be, returned to the sender. It is desirable to have placed in a conspicuous place a receptacle for such packages—either a strong box on the outside of the building or a box inside, reached through an opening in the door. This receptacle should be regularly visited by the sexton, and its contents properly disposed of.

"Then, it is very annoying to call at a church, knowing that the person desired is within and yet unable to reach him or her for lack of a call bell. A bell should be provided for the use of those calling at the church and wishing to reach the sexton, or, it may be, others within. Means should, however, be provided for muffling it or preventing its ringing during service or at any other inopportune time.

"These are small matters, easily and frequently overlooked, but proper attention to them will do away with much annoyance otherwise sure to be experienced at one time or another."

CHAPTER III.

SUNDAY SCHOOL ARRANGEMENTS.

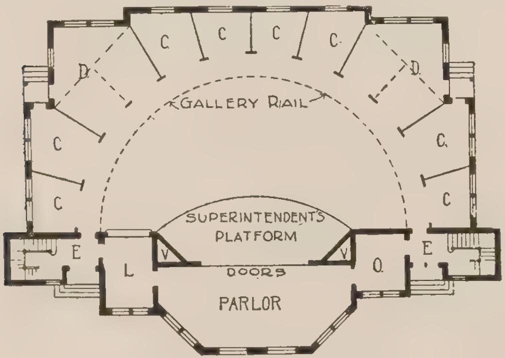
VENDOME.

IN no part of religious work has such great progress been made during the past fifty years as in the Sunday School. The modern Sunday School takes under its care the infant, hardly out of its mother's arms, and young people and adults of all ages. These are graded, according to the size of the schools, into one or more of the following gradations, or divisions, viz.: 1. Kindergarten. 2. Primary. 3. Junior. 4. Senior. 5. Bible. 6. Normal. 7. Relief. Only the larger schools, perhaps, will have the 6th and 7th divisions, and many schools still separate only the primary class from the general school. The tendency in all churches, however, is to give more attention to the training of the young, and it has been found that this work can be carried on more efficiently through the grade sys tem.

In the churches of thirty, and even twenty, years ago, it was customary to provide only one large room for the Sunday School, with perhaps one large class room opening from it, as on Plates XXVI and XXXIV. As the schools became larger and the classes multiplied it was found that the difference in the character of the exercises for the younger and older classes, and the noise and difficulty of securing attention where so many classes were assembled in one room, made it desirable that the classes of the different grades should be separated from each other, and also that the different grades be given rooms by themselves. Then again it is desirable that the whole school, with perhaps the exception of the Kindergarten and Primary Departments, may participate in the opening and closing exercises of the school.

These requirements have led to an arrangement of the Sunday School rooms not known previous to about the year 1866. About that time the First M. E. Church

of Akron, Ohio, was built, the Sunday School portion being arranged by the Superintendent, Mr. Lewis Miller, with the assistance of Jacob Snyder, an Architect of that city, on entirely new lines, to accommodate Mr. Miller's ideas of a graded Sunday School. This plan, the essential features of which are shown by Fig. 19, is now generally known as the "Akron Plan," and has been adopted in a



ORIGINAL AKRON PLAN.
Fig. 19

greater or less degree by many churches and denominations. In a general way, the Akron Sunday School plan consists of a central rotunda, or auditorium, approximately of a semi-circular form, with added width equal to about one-fourth of the radius. Thus, in a theoretical room of 30 ft. radius, the length will be 60 ft. and the width 38 ft., one side being semi-circular. Along the outside of the rotunda are small alcoves, or class rooms, with divisions radiating to the center of the circle. Above these alcoves is a gallery containing another story of class rooms, with a passage of about 3 ft. between the gallery rail and front of class rooms.

The central rotunda is lighted by clerestory windows or skylight, as may be deemed best. The front opening of the class rooms is closed by large doors or curtains, which, when opened, make the class rooms practically a part of the main room, thus enabling all of the classes to participate in the general exercises, while, by closing the doors or curtains, each class is isolated by itself, and all without confusion or changing of seats.

Moreover, the divisions between the class rooms may be made movable, so that two or more rooms may be thrown together to accommodate a large class. For economy, however, and also to diminish the passage of sound, the class rooms are usually arranged to suit the size of the different classes and divided by lath and plaster partitions. The large rooms, occurring at the angles, may be used for the Primary or Bible classes. Each class room is often furnished with pictures, cabinet cases, etc.

The central part should be occupied by those who receive general instruction, generally sub-divided into numerous classes occupying chairs grouped around tables. During the opening and closing exercises these small groups face the Superintendent, who occupies a platform located in the center of the straight side; thus, during the opening and closing exercises, every member is in direct sight and hearing of the single speaker, while during class exercises they are transformed into a collection of small companies, entirely independent of one another.

In order to increase the capacity of the Audience room for special services, the long side of the rotunda, which is usually a dividing partition between church and Sunday School, is often pierced by a large opening, with sliding doors, so that the two rooms may be thrown together when occasion may require. If the axis of the Sunday School is on a line with the center of the opening, the Superintendent's platform is generally placed on heavy castors, so that it may be pushed to one side when the doors are open, as shown on the plan, Plate XXIX.

When the rooms are to be united, however, the author believes it better to arrange the plan of the Sunday School room so that the Superintendent's platform will be either in the corner or at one end, that it may be permanent, and made large enough to receive the piano or organ. In fact, it is very desirable to have a good, large platform in the main school room, so that it may accommodate a small orchestra and be convenient for church entertainments.

In working out the Akron plan for any particular church, the size of the rotunda, number and size of class rooms, etc., will naturally be governed by the size of the school, the size and topography of the lot and by the building fund.

When the lot slopes downward from the front, the Sunday School portion of the building may be dropped, so that the gallery will be on a level with the floor of the Audience room, as was the case in the Akron church.

There are certain practical considerations, however, which apply to this plan, without regard to size, and which should not be overlooked. The first of these is the height of the gallery. Except where the rotunda is very large, say 40 or 50 ft. from the Superintendent's platform, the height of the gallery floor back of the rail should not be more than 9 ft. above the main floor, and when the rotunda is not more than 25 ft. deep the height of the gallery should not be more than 8 ft. 6 ins. Many Architects make a mistake in getting the gallery too high, both in the Sunday School room and in the church. In a small room it will generally be necessary to make the

entire gallery level from the rail back. In larger rooms the gallery rail may project 5 ft. beyond the class rooms and be arranged in two steps, with the floor of the class rooms raised still another step. This affords an opportunity for the classes in the gallery to sit around the front during the opening and closing exercises, thus bringing them more in touch with the school below. Another practical consideration is the closing of the front openings of the class rooms. This may be accomplished either by folding doors, flexible partitions rolling horizontally (*i. e.*, with vertical shaft), or by curtains. Folding doors, however, are the most convenient, as they can be more readily opened to admit the officers of the school during class exercises, and may also have glass panels, through which the Superintendent and class may be visible to each other. For the gallery class rooms it is not really necessary to close the openings, although portieres will be found of advantage in benefiting the acoustics and in producing a decorative and cosy effect.

If it is deemed advisable to have movable partitions between part of the class rooms, rolling partitions, winding on a coil either at one side or above the opening, are the most practical device.

Ample Stairways should be provided in vestibules at each side of the rotunda leading to the gallery, and in a large school it will be found convenient to have a three-foot stairway leading directly from the rotunda.

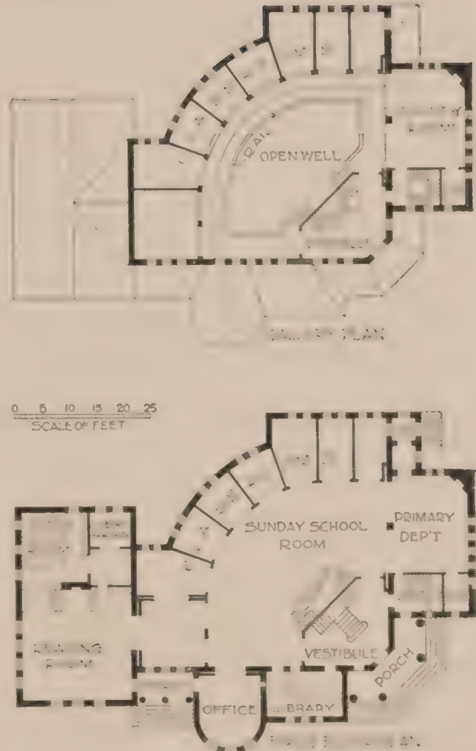
INDEPENDENT SUNDAY SCHOOL BUILDINGS.

Very large Sunday Schools can undoubtedly be best accommodated in a building entirely independent of the church, as it is then possible to obtain better lighting and a better arrangement of class rooms, platform, musicians, gallery, stairways, etc.

Fig. 20 shows a plan for such a building designed by George W. Kramer, Architect, of New York City. Mr. Kramer became associated with Mr. Snyder early in the development of the Akron and combination plan for churches and Sunday Schools, and has had a great deal to do with their later development, and was one of the first Architects to design a church with the pulpit in a corner of the Audience room. In the Union M. E. Church, New York City (see Fig. 13), he has carried the combination plan farther, we believe, than has been done elsewhere. After having made a great number of plans on the Akron system, Mr. Kramer states that in his opinion the plan shown by Fig. 20 gives the ideal arrangement for a Sunday School building with reading room. Fig. 21 shows the ground plan of a Sunday School chapel at Newton, Ga., designed by Mr. Charles W. Bolton, of

Philadelphia, in which the semi-circular form is carried to its full limit.

Other Arrangements. Not every society can afford to provide for the Sunday School on the Akron plan, as to provide for a school of four or five hundred on this plan requires a good-sized building in itself. Many churches of comparatively small membership now maintain Sunday Schools numbering two and even three times the church membership, and it is often a serious problem how to provide for such a large school. The Boulevard Congregational Church, of Denver, Colo., whose building is illustrated on Plate XXIII, has a Sunday School numbering nearly 600, while the average attendance on the church services does not exceed 200. The church could not afford to build on the Akron plan, and so it was arranged to accommodate the senior department in one large room on the main floor, with a large parlor connected with this room by vertical sliding doors. The Kindergarten, Primary and Junior departments meet in the basement, each department being by itself and each having its own Superintendent. Some of the adult classes assemble in the church auditorium, which communicates with the main Sunday School room. In this way a large Sunday School is well accommodated in a building no larger than would be required for a school of not more



PLAN FOR SUNDAY SCHOOL BUILDING
Fig. 20. GEO. W. KRAMER, ARCHITECT

than 200. True, there is a disadvantage in that all of the school cannot participate in the general exercises, but the arrangement has been found very satisfactory for Sunday School purposes and admirably adapted for social entertainments. The main school room makes an excellent lecture room, and the Junior room is often used as a din-

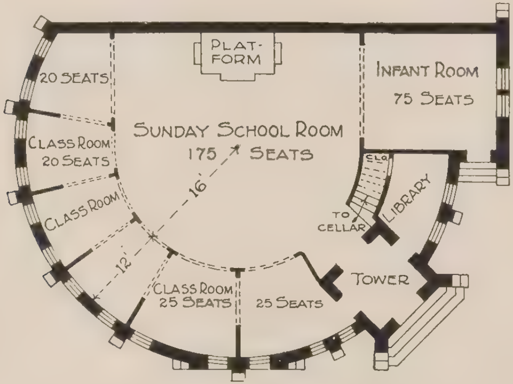


Fig. 21. CHAS. W. BOLTON, ARCHITECT.

ing room, being free from columns, and the Kindergarten room is used during the week as a public reading room.

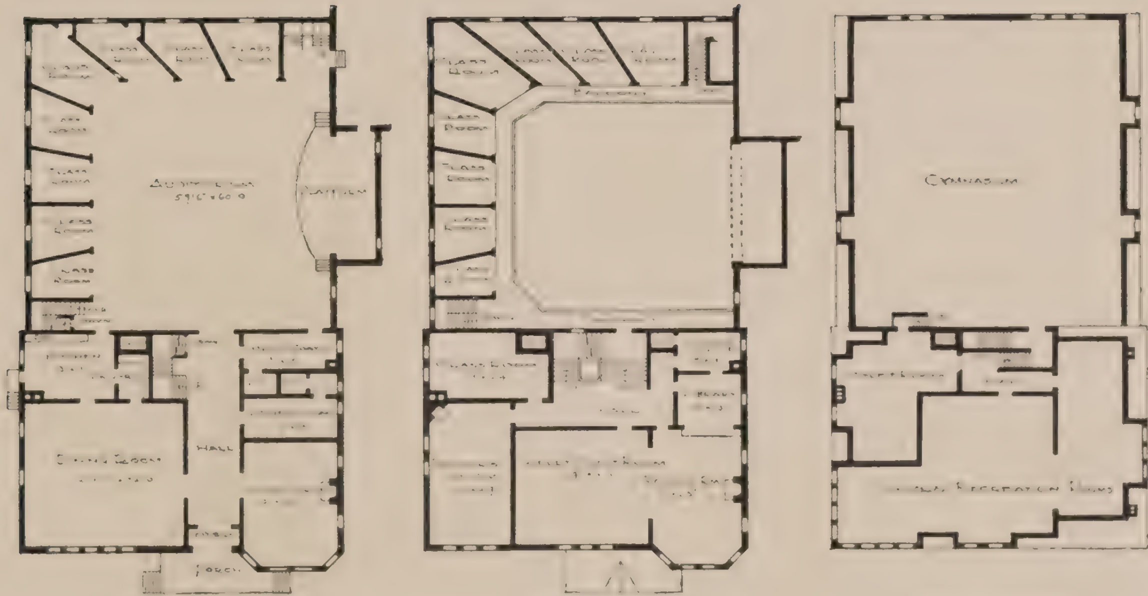
Whatever arrangement is followed, the rooms should be planned so as to have plenty of sunlight, be easy of access, and, as far as possible, independent of the main Audience room.

BUILDINGS FOR RECREATION AND INSTRUCTION.

To successfully bring the modern church into vital connection with the people of to-day, and especially the working people, seems to require that the church shall provide for their mental and bodily recreation as well as for their spiritual needs. This can undoubtedly be done most successfully with the aid of a building devoted exclusively to this part of the church work.

Fig. 21A shows the three-floor plans of the "Congregational House" of the Congregational Church of Adams, Mass. This building was designed for the purpose of giving "such recreation to the people as can be appropriately connected with Christian work." The following description of the building is taken from the Congregational "Church Building Quarterly," of January, 1896:

"On the right of the entrance is the parlor, with a coat room in the rear, and on the left are those indispensable adjuncts of the modern church, the dining room and kitchen. The Sunday School room is at the end of the hall, with sixteen class rooms, which can be opened to



FIRST FLOOR. SECOND FLOOR. THIRD FLOOR (Attic).

PARISH HOUSE OF THE CONGREGATIONAL CHURCH, ADAMS, MASS.

Fig. 21 A. GARDNER, PEYNE & GARDNER ARCHITECTS

the general assembly room or closed each by itself. Here, also, is a space for an audience of 700 persons, within sight and hearing of the speaker's desk. Over this room is the gymnasium, so that the two halls occupy the whole height of the building. There is a spacious pastor's study on the second floor also, and rooms for the King's Daughters, the men's Bible class and for social purposes or a library. In the third story there are two billiard tables, which seem to belong there as naturally as if they had always been associated with the society of Puritan churches. The lockers and baths, in close proximity, suggest that cleanliness and health are next to, and even a part of, godliness. In the basement there are bowling alleys. About the entire building there is an air of enterprise, which seems to promise such further additions as will advance the general work. Nearly $30.000 have already been spent, and a large annual outlay will be needed in addition to sustain the work."

CHAPTER V.

SEATING AND EQUIPMENT.

FLOORING, FURNITURE, ETC.

PEW END.

SEATING *of Main Audience.* The method of seating and the kind of seat to be used is a matter for each church to determine, the choice being often governed by sentiment and somewhat by the character of the service.

In Episcopal churches pews or benches are used almost exclusively, but in churches of other denominations pews, folding chairs and combinations of the pew and individual chair are used, according to the choice of the society.

The arrangement of the seats, however, is a question that should be determined principally by the shape of the room, convenience of exit and the means of the church. For a small church straight pews, arranged in rows of uniform length, answer very well, and are cheaper and afford greater seating capacity than any other arrangement. When the width of the audience room exceeds 40 ft., or if the pulpit is located in one corner, or the room is octagonal in plan, the seats should either be set on a curve, having the center at some point back of the pulpit, or on straight lines tangent to such curves. Circular seating is the more comfortable, and should be adopted when the means will permit. On the circular plan each row of seats should be struck from the same center, so that the arcs will be concentric and a uniform distance apart.

The spacing of seats should not be less than 2 ft. 8 ins. from back to back for the pews, and not less than 2 ft. 6 ins. for the folding chairs. Where the greatest comfort is desired it is best to increase these dimensions by one to two inches.

Bowled Floors. When the seats are arranged in arcs or chords of circles it greatly increases the comfort of the audience, and to some extent the acoustical properties, to have the seats raised as they go back from the pulpit. This necessitates a bowled floor, *i. e.,* a floor that is in-

clined from the center outwards, like the rim of a bowl or saucer.* The degree of incline desirable depends somewhat upon the size of the church and the elevation of the pulpit and choir. It should not be too great, however, as an incline of more than ¾ inch in a foot is unpleasant to walk over.

The author considers a rise of from ½ inch to ⅝ inch per foot as about the most desirable for ordinary churches. If the church is quite deep the back seats may be raised in a series of steps, as in a gallery. Whatever the inclination, the floor should be so constructed that any given row of seats will be on a level from end to end.

When the seats are arranged straight across the room the floor should be a simple incline from front to back.

Only the portion of the floor covered by the seats (and the aisles between and at each side) should be inclined, the floor back of the pews and at the entrances and for 10 to 12 feet in front of the pulpit being level.

Aisles. The number and position of the aisles must be considered in arranging the seating, and must be laid out on the plan before the actual seating capacity can be determined. In locating the aisles the first point to be determined is whether or not there shall be a central aisle. The advantages and disadvantages of a central aisle have been much discussed.

Some pastors do not like the blank space of the aisle directly in front of them, preferring to have a group of faces there. Other ministers say that they preach as much, or more, to the right and to the left, and that if the aisles are there instead of in the center, they preach more to the aisles in the aggregate than if an aisle were in the center and groups of faces on either side. While the preacher views the matter from his standpoint, congregations generally desire a broad center aisle for such occasions as weddings and funerals especially.

In Episcopal, Catholic and Jewish churches a wide aisle down the center is necessary for the ceremonies of the church. In other denominations it is probable that a majority of the churches built within the past thirty years are without a central aisle.

Except in very small churches, there should always be an isle all around the room (except sometimes at the back of the room). Where the seats are straight across the room the aisles should be spaced from 12 to 18 ft. apart, according to the width of the room. With semi-circular seating, aisles should be placed so that the dis-

* If the floor is inclined and chairs are used for seating, the floor must be bowled, but where pews are used, with a slight curvature, they may be set on a straight incline, although the seats will not be level. The pews in the buildings shown on Plates XXXVI and LII are set on a straight incline and are very comfortable. When the pews curve as much as shown by the Plans, Plate XX, it is really necessary to bowl the floor.

tance between any two aisles will not exceed 18 ft. To accomplish this it will generally be necessary to introduce short aisles extending only part way from the back toward the front. (See Plates XXVII and XXVIII.) In regard to the width, the principal aisles should be at least 4 ft. in the clear, and in many churches the center aisle is 5 ft. wide. Short aisles may be 3 ft. wide, and the outside aisles 30 ins. wide. With circular seating, where it is desired to obtain the maximum seating capacity, the outer aisles may be reduced to 2 ft. in the clear, as the ends of the pews are generally on a considerable angle with the aisle, which materially increases the effective width.* It is a good idea to taper the principal aisles, making them wider at the back than at the front, such aisles being more effective for exit than aisles of uniform width.

Estimating Seating Capacity. On account of the varying amount of aisle space, etc., the exact seating capacity of any proposed room can only be determined by drawing the seats to a scale on the plan, allowing 18 ins. to a person in pews and 19 or 20 ins. for chairs.

For approximate purposes, however, the seating capacity or required size of room may be determined by allowing from 7 to 8 square feet to each seat when on a curve, and 6 to 7 square feet to each seat when straight, the smaller numbers being used only for large rooms. This allows for the aisles and pulpit platform. Lecture rooms and narrow rectangular rooms will usually require but 6 square feet to each person. The seating capacity of churches is almost always quoted much greater than it really is. The capacity given for the designs herein shown may be relied upon as being without exaggeration.

KINDS OF SEATING.

Pews. In the early churches of this country the seats were arranged in the shape of square or rectangular boxes, with partitions from 3 to 4 ft. high and a solid door opening into the aisles. Inside of these boxes seats were built against the partitions, often extending all around the box. Each box or pew was intended to accommodate one family. In many churches these pews were considered as private property, descending from father to son, as an appurtenance to and sold with the residence. After a time straight pews were introduced, arranged in parallel rows. These pews had straight backs and plain seats, and were designed without much regard to comfort. With the shortening of the length of the service, more attention has been paid to the physical com-

* Where pews are placed on a curve it is customary to set the ends at right angles to the body. Owing to the flare of the back and the increased distance from the front of the seats when the ends are not set at right angles, placing the ends parallel with the aisle is almost an impossibility, and as a matter of fact it is not objectionable to have the ends at an angle with the aisle. They should always, however, come to a line either at the front or back.

fort of the congregation, and hence we find the modern pew designed with every regard for ease.

In the early days the pews were built by the carpenter or joiner, but with the specialization of business enterprises the manufacture of pews has become a special business, so that they are now included in the furnishings and are purchased in much the same way as furniture, except that the seats must be made up in lengths or curvature to suit each individual plan. Firms making a specialty of this business carry in stock a varied line of pew ends and all of the necessary fittings, and the body of the pew is built after a stock pattern, the only variation in the manufacture for any particular church being in making up the pew bodies to the various lengths required by the seating plan and building them to the required curvature when circular seating is adopted.

For wealthy churches the pew ends are often made to order from the Architect's design, but as this involves an extra expense the majority of churches usually choose a regular pattern. The pew bodies may also be made to order, although little can be gained thereby. For small Episcopal churches the pews are often made by the carpenter, with plain seats and backs of inch boards and ends sawed out of plank, the pews in Episcopal churches being almost invariably straight.

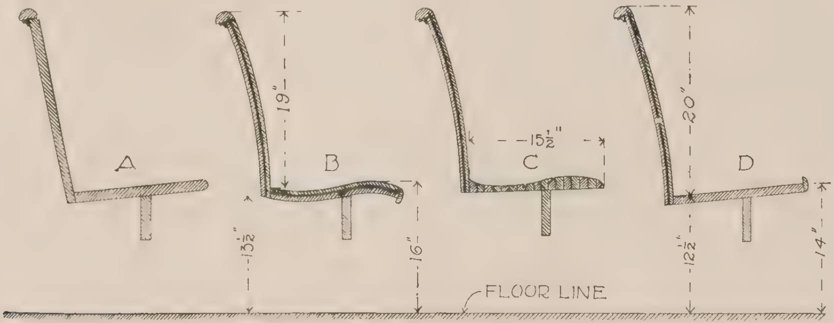
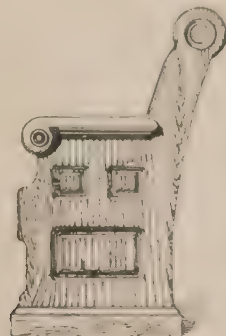


Fig. 22.

Fig. *22* shows sections of the pew bodies now most

generally used in non-liturgic churches. The backs are made laminated, in either three or five layers, the grain of the wood in the center layer running vertically and in the outer layers horizontally. These layers of wood are cemented together under pressure and in forms giving them the proper curvature in both longitudinal and transverse sections.

Fig. 23.



PEW END

Fig. [illegible]

The sections shown in A and B are for straight seats without cushions. Sections C and D are for circular pews, D having a flat seat for cushions. Fig. 23 shows a special laminated back made by the Manitowoc Seating Company. Pews exceeding 10 ft. long should be divided by a partition of the same shape as the ends, but generally plainer, and there should be intermediate supports under the seat from 3 to 4 ft. apart. The ends and supports should be fastened to the floor by iron brackets.

Fig. 25.

When the Audience room is finished in hardwood the pews should be made of the same wood, and the design of the ends should conform with the architectural style of the interior. Every pew should be fitted with a book rack, and envelope holders, foot and kneeling stools,

hat and umbrella racks may be had if desired. It is also a convenience to have numbers on the pew ends; they may be either carved from the wood, or metal numbers may be used.

Individual Seating. It has become quite a common custom to seat the audience room of churches with folding chairs similar to those used in theatres, and quite often chairs are placed in the gallery, even when pews are used on the main floor. Various styles of these chairs are made to meet the means and needs of the purchaser. Nearly all, however, have iron standards and frames, and most of the chairs in common use have laminated wood seats and backs.

The regular opera chair is made so that the back assumes a vertical position when the seat is raised, and is always provided with arms. The chairs generally used for churches are called assembly chairs, and the backs are stationary. Arms are generally placed between the chairs, although they are also often omitted. Fig. 25 shows a typical assembly chair, such as is used in churches, with both laminated and upholstered seat, although more elaborate chairs are often used. The chairs are fastened together in sections and screwed to the floor.

An arrangement of individual seating that combines the advantages of the individual seat with the appearance and association of the pew is known as the Folding Seat Pew, of which one form is shown in Fig. 26.

Regular pew ends are used at the aisles, and for divisions between pews, but each sitting has an individual folding seat and curved back. No arms, however, are used between the sittings. Such seats may be obtained

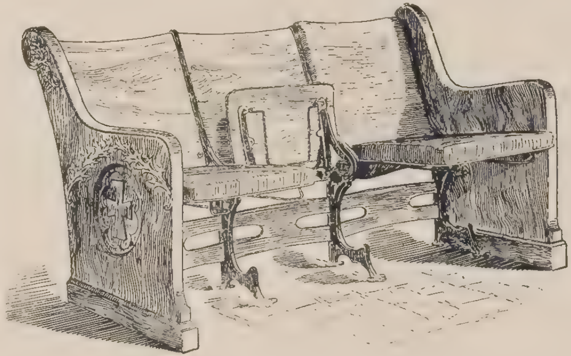


Fig. 26.

with upholstered seat and back, upholstered seat and veneered back, or veneer back and seat. Assembly chairs or the folding seat pew may be placed on a circle without extra cost over straight seating.

Another form of seating, known as divan seating,

combines three, four or five individual seats in one, the back being curved and stationary and the seat folding.

All of these forms of seats are generally provided with hat racks and projections on the standards for umbrellas and canes. A book rack should be placed on the back of at least every other seat.

Assembly chairs are made 19, 20, 21 and 22 ins. wide, and in arranging them in rows where the aisles converge the ends are made to come in line on the aisles by using a few chairs that are either narrower or wider than the standard width, which is usually 19 or 20 ins.

Comparative Advantages of Pews and Chairs. Pews possess the advantage over chairs in that they preserve the family relations, and in a congregation composed to a considerable extent of children more persons can be seated in a given space in pews than in chairs.* Pews are also somewhat cheaper, and give a more ecclesiastical effect to the room.

Chairs, on the other hand, are, as a rule, more comfortable, and every chair counts a seat, as no person can well occupy two seats or crowd his neighbor. There is an objection to having arms between chairs, in that they prevent small children from reclining on their parents when they become tired, as they often do. Considering both appearance and utility, the Author is inclined to recommend the folding seat pew as giving the greatest satisfaction.

Cushions. In the wealthier churches the pews are usually provided with cushions. These are filled with

A COMMUNION CHAIR

hair, elastic felt, cotton felt, excelsior, moss, tow and fibre, the materials rating in comfort and durability practically in the order in which they are named. The elastic felt, when properly prepared, is claimed to be proof against moth or insects, and this, with the fact that it does not mat or pack, makes it practically the best filling, when

* As an instance of the comparative seating capacity of chairs and pews, the pews shown on the first floor plan, Plate LIII, would easily accommodate 830 persons, while 756 chairs were actually used.

considered from the standpoints of sanitation, economy and comfort.

The coverings used are mohair plushes, both crushed and plain; linen velours, corduroy, corduroy plush, mohair, damask, etc. Of these the corduroy plush is probably the most popular, is obtained in all colorings, claimed to be moth proof and possesses great wearing and enduring qualities, while the mohair plushes unquestionably make the finest grade of cushions. The popular styles of finish are the "square corded" and the "Turkish," tufted in patterns to suit the taste. Hassocks and kneeling cushions, made of materials and styles to correspond with the cushions, are also considered a necessary part of the furnishings for wealthy churches.

Pulpit Furniture. In most of the non-ritual churches the pulpit platform is usually furnished with a small pulpit or reading desk, about four chairs, two of which are usually larger than the others, and a small stand. Sometimes a divan or sofa is placed back of the pulpit in place of the two center chairs, but chairs are usually preferred, and, if properly designed, they are certainly more dignified and appropriate for a place of worship.

A communion table, sometimes called the altar, is placed on the floor directly in front of the pulpit, and a chair, to match the pulpit chairs, at each side. When there is an abundance of means the communion table, pulpit and chairs are often made from special designs prepared either by the Architect or by some firm that makes a speciality of such work, but for most churches the pulpit furniture is purchased from the parties who furnish the pews and selected from stock designs. When selecting this furniture the building committee should seek the advice of the Architect, that the furniture may be in keeping with the architectural treatment of the building.

Seating of Sunday Schools and Class Rooms. For the seating of the Sunday School room, especially when the room is also used for prayer meetings, entertainments, etc., single folding chairs have been found to give the best satisfaction, as the chairs can be arranged in circles around the teacher for Sunday School use and easily rearranged in straight rows or on circular lines for prayer meetings or other gatherings. Folding chairs can also be quickly folded and packed away at one side of the room when it is desired to have the floor space entirely clear. About the only objection that can be offered to single chairs for seating is the liability of noise caused by scholars moving the chairs during the exercises.

This may be avoided by fastening two or three of the chairs together by a board screwed to the legs, but when this is done the chairs cannot be arranged in circles,

although they may be arranged in hollow squares.

Chairs for the Sunday School and class rooms should be light and strong. Figs. 27 and 28 represent two kinds that are very extensively used. The chair shown in Fig. 27 is believed to be the stronger of the two, but the other

Fig. 27.

Fig. 28.

is the more comfortable, and will stand any reasonable usage. Solid wood chairs, a little better than the ordinary kitchen chairs, are sometimes used; but they are heavy to handle and cannot be packed as closely, for which reason it is much better to pay a little more money for a good folding chair.

For small churches having but one room, in which the same seats must be used for church, prayer meeting

KINDERGARTEN CHAIRS.
Fig. 2

and Sunday School, settees, half of which have reversible backs, will be found very convenient, as by alternating the reversible backs with fixed backs the seats may be arranged in pairs facing each other for the class, and by

reversing the reversible backs they will all face the platform for church and prayer meeting service. Settees possess the advantage over chairs in that while a settee 8 ft. long will easily seat six children, not more than five chairs can be put in the same space. There is also less liability of noise during the service than with chairs. Settees with veneered back and seat and ornamental wood ends, corresponding to pew ends, may be had, if desired.

For class rooms light settees, with folding seats, may be used, as the seats all face the teacher, who sits in a chair.

For primary and kindergarten grades small wooden chairs, like the one shown in Fig. 29, are commonly used. They are made in two sizes, 12 and 14 ins. high. If it is desirable to have chairs that may be packed in a small space, small folding chairs similar to that shown in Fig. 27 can be obtained.

In many Sunday Schools each teacher is provided with a small table, upon the top of which is painted the number of the class and in the drawer of which the teacher may conveniently keep needful appliances for her work. Such drawers should be provided with two keys, one for the teacher and one for the Superintendent.

Cost of Pews and Church Furniture. The following data will give an approximate idea of the cost of pews, chairs, etc., the prices being for delivery at Chicago, New York and St. Louis. For other points the freight charges may make a slight difference in the cost at the building. The exact cost can only be determined by submitting a plan of the seating or schedule of furniture desired to the manufacturer.

The best veneered pew bodies, with curved backs and seat, oak finish, cost about 82½ cents per lineal foot for straight seating, and $1.20 when formed to a curve. This price includes all necessary supports. Pew bodies with plain seats for cushions cost about 12 cents per foot less than the built or veneered seats.

Pew ends vary in cost from $1.50 to $6 each. A neat pew end can be obtained for $3. Divisions cost three-fourths as much as the ends. Book racks, 24 to 30 ins. long, cost about 30 cents each.

To estimate the cost of pews, approximately, get the total length of pew bodies from the plan, measuring along the longest edge; multiply this by the price per foot and add the additional price for each end and division and for each book rack.

A good assembly chair, with permanent veneered back, folding veneered seat, with hat rack and arms between seats, can be purchased for from $1.85 to $2 each

when connected in sections of from five to twelve. Without arms, 10 cents less. Chairs with upholstered seat vary in cost from $3.50 to $6 each, and with both seat and back upholstered, from $5 to $9. A good, serviceable folding chair, without arms, for Sunday School purposes, may be purchased for from $1.50 to $1.85. With veneered back and seat and arm rest, for $2. Kindergarten chairs, like Fig. 29, painted red, cost about 75 cents each. Pulpits about 23x33 ins. on top, with adjustable top, all in oak, cost about $30.

A good oak communion table, with inscription, will cost about $25. Platform and communion chairs vary in cost from $15 to $40 each.

Stalls, altars, lecterns, etc., for Episcopal churches, vary so much in design that it is impossible to give any definite idea of their cost.

CHAPTER V.

ORGANS, STAINED GLASS, ETC.

ORGAN AT
ST. LUKE'S HOSPITAL.
HUTCHINGS MFG. CO., BUILDERS,

NO church can be considered as completely equipped for its purpose without a good organ, as only by it can sacred music be given the tone and volume so desirable for praise or worship.

To obtain the result desired, however, the organ must not only be of good quality, but must be of a scale proportionate to the size of the room, favorably situated and cased and decorated in harmony with the rest of the building.

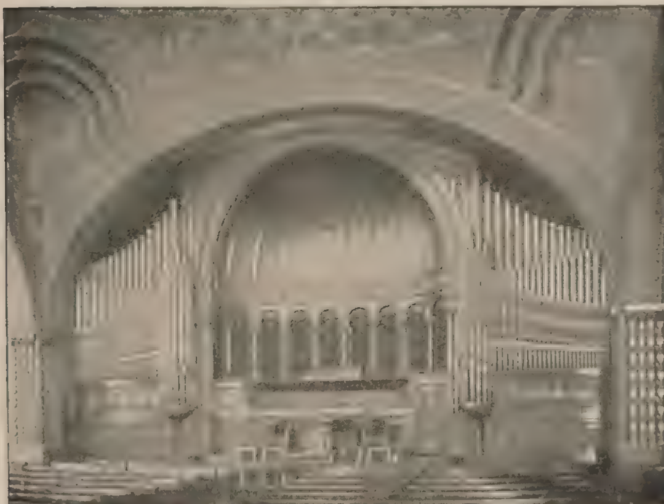
The best position for the organ is where it can be central, elevated and unconfined. It should also be either at the back or at one or both sides of the choir. When the choir is directly back of the pulpit platform the organ should either be directly back of the choir, or, if this is prevented by the size of the lot, it may be divided, half being placed at one side of the choir and half at the other side. Such an arrangement is shown in Fig. 30.

In any case the choir and organ should be symmetrically disposed about the center line of the church and pulpit platform. When the choir is at one side of the pulpit the organ should be placed as near the choir as possible.

The organ, usually occupying so prominent a position in the view of the congregation, architects and organ builders have both recognized its value as a decorative feature and especially of late there has been an endeavor to keep it in harmony with the general decorative treatment of the church. By the courtesy of several prominent organ builders, we are able to present a number of organ fronts.

In Plate A is shown one side of the great organ erected by the Austin Organ Company, of Hartford, Conn., in "All Saints Episcopal Cathedral," Albany, N. Y. This instrument was the offering of the "Women's Cathedral League" in honor of their president, Mary

Parker Corning, and is a very large instrument, considered one of the finest in the country. The fronts, which are one on each side of the choir, extend from



DIVIDED ORGAN, CHRIST CHURCH, PITTSBURG, PA.
Fig. 30.

the floor through the triforum to the clear-story, the speaking pipes being placed for the most part behind these screens. This organ has no bellows, but the wind is supplied by an electric motor of twenty horse-power, having four circular fans, which are situated in the crypts. The wind is conveyed thence by large metal ducts which run through the center of the stone columns of the choir arch to the various points required. The action of the keys is electric, connecting the console with the different portions of the instrument. There are four manuals and a large pedal organ. The stops are controlled by "stop-keys" arranged in two rows immediately above the solo manual, directly under the eye of the organist. The diapasons are of immense scale and weight, whilst the "solo" and "pedal reeds" are on very heavy wind.

In Plate D is shown another organ built by the same company. It is in Trinity Church, Hartford, Conn., and the front was designed by Mr. Henry Vaughan, of Boston. The choir organ is on a screen behind the north front. There is also another front not shown opening into the transept. The main portion of the organ is contained in an organ chamber behind the south front. There is also another case and front facing the south transept, which the cut does not show.

On Plate B are shown two organs designed and built by the Hook-Hastings Co., of Boston—the one

on the left that of the Church of Immaculate Conception, Boston, Mass. This occupies an ideal position in the wide-open gallery; the high-vaulted ceiling, the perfect acoustics of the large church allow in an unusual degree the full development of music both of organ and choir.

The beautiful exterior has been greatly admired for its appropriateness of style and character. It is 35 feet wide, over 40 feet high, and 16 feet deep. The console is placed forward, close to the gallery rail, to allow the organist to face and direct his large choir. Its five Manual and Pedal keyboards, with its 116 stops, couplers, etc., represented by a bewildering array of Registers, Pistons, Tilting-Tablets, Combinations, Swell Pedals, etc., controlling various electric and pneumatic devices, indicate the great advance of the organ building art and what ease and full control the master organist may now have over the resources of such an immense instrument.

Wind is supplied by three large bellows on different pressures, with supplemental feeders and reservoir actuated by large water motors. The organ is three stories. On the upper one the Swell and Solo organs are placed side by side, while underneath and in front is the Great organ from which the loud effects are obtained. Back of this is the Choir organ and still lower are the large wind reservoirs.

No other organ in New England is so well known, and by highest musical authorities it is considered as having no superior in this country.

On the same plate is the organ of the Second Presbyterian Church, Williamsport, Pa., built by the same firm.

This organ exterior, with its two large towers, supported by heavy corbels, makes a grand display. The large pipes are supported on a lower level than the others, which was necessary to accommodate them. The half-tone picture shows how well it is designed to be in keeping with its surroundings—making a picture of comfort, elegance, and good taste. It is the third instrument furnished this church by this firm.

On Plate E are shown two organs, one the exhibit organ of the Hook-Hastings Co. in the Liberal Arts Building, World's Fair, St. Louis, and the line drawing accompanying it that of Cornell University, Mt. Vernon, Ia. Both of these are medium-sized instruments, such as are most frequently called for. The first received the grand prize for artistic voicing and high excellence throughout. The cut does not do justice to the fine points of the Cornell University organ. This

ORGAN OF ALL SAINTS' EPISCOPAL CATHEDRAL, ALBANY, N. Y.

PLATE B.

ORGAN IN CHURCH OF THE IMMACULATE CONCEPTION,
BOSTON, MASS.

ORGAN IN SECOND PRESBYTERIAN CHURCH,
WILLIAMSPORT, PA.

HOOK-HASTINGS CO., BUILDERS, BOSTON, MASS.

ORGAN OF FIRST CHURCH OF CHRIST SCIENTIST,
CENTRAL PARK WEST AND 96TH ST., NEW YORK.
FOUR (4) MANUALS SIXTY-NINE (69) STOPS.

ORGAN AT VASSAR COLLEGE
POUGHKEEPSIE, N. Y

THESE ORGANS WERE BUILT BY HUTCHINGS-VOTEY ORGAN CO., BOSTON, MASS

ORGAN AT ST. THOMAS P. E. CHURCH, NEW YORK.
MADE BY HUTCHINGS-VOTEY ORGAN CO., BOSTON, MASS.

organ is placed in the choir gallery, showing an elegant front, comprising groups of metal pipes, beautifully illuminated, supported by casing of oak, and forms an attractive feature in this large and handsome chapel.

The little organ shown at the commencement of this chapter is a small two-manual electric organ, with movable console, and was built by the Hutchings-Votey Co., of Boston, Mass. On Plate C are two organs by the same firm; that to the left is the organ of the Church of Christ Scientist, Central Park West and Ninety-sixth street, New York.

This is a four-manual electric organ, with sixty-four speaking stops, the wind pressures of which vary from 3⅛ to 10 inches. There is, in addition, an Echo organ of five stops, and a beautiful set of chimes, which can be played from two of the manuals.

The organ is situated back of the reader's platform, the console being of a type known as movable, and has 210 feet of surplus cable, which enables it to be operated from any part of the auditorium. The main organ is placed in a recess back of the pulpit platform, 60 feet wide, 35 feet high, with an average depth of 12 feet.

The opening into the auditorium is filled with groups of front pipes finished in dull gold, which harmonizes very beautifully with the sumptuous interior decorations.

The Echo organ is situated at the opposite end of the building and is in a recess above the ceiling. The sound from Echo organ penetrates through a grill work in the ceiling. The situation of the Echo organ is particularly good. While sufficiently remote to give the auditor a feeling of distance to the tone, its effect is wonderfully clear and beautiful, and in great contrast to the more massive tone of the main organ. One can easily imagine the Vox Humana to be a choir of singers situated at a distance from the auditorium and the chimes might well be considered to be placed in the tower.

The organ of Vassar College is by the same firm and is shown on the same plate.

This organ has three manuals and forty-seven speaking stops. The action is electric, the console of movable type. It also has a self-playing æolian attachment.

This instrument has three wind pressures, 4½, 5 and 7 inches. It is situated in a circular chamber back of the pulpit, the choir gallery being placed between the pulpit and the organ.

The case is majestic in design and contains much

elaborate carving, is made up of groups of pipes supported by carved brackets and surmounted by carved caps.

On Plate F is shown another interesting organ—that of St. Thomas' P. E. Church, New York, which was burnt down a short time since. This is also one of the Hutchings-Votey instruments.

This was a four-manual electric, sixty-three stop organ, with wind pressures varying from three to eight inches. It had a movable console and over two hundred feet of surplus cable enabled the organ to be played from any part of the church. It was divided—the Swell and Great organs on the left-hand side of the chancel, and the Choir and Solo on the right-hand side. It also had an Echo organ, with a "Duplex Chest," which gave it the variety of a two-manual Echo organ.

This church was totally destroyed by fire in August, 1905.

If the organ is elevated the tone is more generally diffused throughout the building, and is not so overpowering to the portion of the congregation near it.

The height above the gallery or platform should be sufficient for the construction of the organ and allow space above when possible.

When an organ is crowded in under a low ceiling or roof the tone is apt to have a severe and disintegrated character, and an organ so placed is more liable to be out of tune from the effect of the higher temperature which surrounds the pipes standing close up to the ceiling. Free circulation of air through and around the organ should be provided to prevent dampness and to keep the temperature as even as possible in all places. For the same reason the space inclosing the organ should be lined with matched boards. Windows close to the organ should be avoided, on account of their chilling effect on the temperature.

TABLE OF DIMENSIONS FOR ORGANS COSTING FROM $1,500-$15,000.

COSTS	FT. IN WIDTH	DEPTH	HEIGHT
$ 1,000	7'0" to 8'0"	5'0"	12'0" to 14'0
$ 1,500	10'0" to 11'0"	7'0"	12'0" to 16'0"
$ 2,000	11'0" to 12'0"	7'6"	14'0" to 18'0"
$ 2,500	11'0" to 12'0"	8'6"	14'0" to 20'0"
$ 3,000	12'0" to 14'0"	9'0"	14'0" to 21'0"
$ 3,500	14'0" to 16'0"	8'0" to 10'0"	15'0" to 21'0"
$ 4,000	14'0" to 17'0"	8'0" to 10'0"	15'0" to 21'0"
$ 5,000	15'0" to 18'0"	9'0" to 11'0"	18'0" to 25'0"
$ 6,000	15'0" to 18'0"	9'0" to 12'0"	18'0" to 25'0"
$ 7,000	20'0" to 22'0"	10'0" to 12'0"	20'0" to 25'0"
$ 8,000	21'0" to 23'0"	11'0" to 13'0"	20'0" to 25'0"
$ 9,000	21'0" to 25'0"	11'0" to 14' "	20'0" to 25'0"
$10,000	23'0" to 26'0"	14'0" to 15'0"	20'0" to 25'0"
$12,000	25'0" to 30'0"	15'0" to 16'0"	22'0" to 25'0"
$15,000	28'0" to 32'0"	16'0" to 18'0"	25'0" to 30'0"

The dimensions given of the different organs show in a general way what space is required for them. These dimensions are subject to considerable modification, according to the needs of the place in which the organ is to stand.

When the depth (from front to back) is small, a greater width is required. When the height is small, generally more depth is needed.

For instance, in the figures given above for a $5,000 organ, a space of 18 ft. in width, 10 ft. deep, 21 ft. high would be well; but if only 15 ft. be allowed for width, we would need a depth of 11 ft. A height of but 18 ft. would barely suffice; 21 ft. would be enough; 25 ft. would allow a surplus when required for appearance. The same explanation would apply to all the sizes.

It is particularly desirable that ample space should be provided for the organ, not only to insure proper speaking room for the pipes, but also to allow the tuner freedom of access. For economy the space should be rectangular in plan, although a competent and experienced organ builder can adapt an organ to almost any shape provided there is sufficient space.

About the smallest space in which any organ can be built is 6 ft. wide, 5 ft. deep and 10 ft. in height. This would accommodate a single manual organ with six stops. The back of the seat is usually 3 ft. from the front of the organ.

Selecting an Organ. A church organ is an intricate and complicated instrument, and as such organs are seldom carried in stock, but must be made after the order is given, they cannot be seen or tried before purchasing; hence the selection is a matter of some risk. The best [illegible] of the particular church, if possible, and request him to prepare a specification or schedule of the stops, mechanical accessories, details of construction, etc., that are deemed necessary, and then submit this, with a plan of [illegible] respond directly with some organ manufacturer or builder whose output is known to be of a high quality, stating how much can be paid for an organ, for what purposes the organ is to be used, and inclosing plans for the building and request that he submit a specification for an organ such as he thinks will best meet the needs of the

A MODELED OPALESCENT GLASS WINDOW.

Pla[illegible] Presbyterian Chu[illegible], Mid[illegible]etown, Ohio. Designed and made [illegible] F. Androu[illegible]te & Co., [illegible] to 31 South Clinton St., Chicago, Ill.

[illegible] age cost of a window of this size (12x16 feet) and character would be [illegible]. The illustration [illegible] made from a photograph of the window take[illegible] position.

church and come within the appropriation. It is much safer to rely upon the advice of an honorable firm than for the committee themselves to undertake to dictate in the matter. Above all, do not select an organ merely because it is the cheaper for the same number of stops, or because it has more stops than another. The largest number of pipes and stops does not necessarily imply the best organ, as unless the voicing and mechanical construction is perfect the instrument will not be satisfactory.

It should also be remembered that the church is not built for the display of the organ. The organ should be adapted to the house to which it is an accessory and should be in scale proportionate to the room. The volume of a small organ can never satisfactorily fill a large church, and the best effects of a large organ are only possible in a large church. In all cases the builder must consider the space, the position, the surroundings, and what will be required of the organ to properly determine the strength of the tone or volume and voicing.

The case for the organ should be of material and design corresponding with the architectural treatment of the room, and the design should either be made by the architect or be subject to his approval.

To secure a good organ sufficient time must be allowed for the proper execution of the work, and hence the order should be placed as soon as the amount of money available can be determined.

STAINED GLASS.

In modern churches the sash are generally filled with pieces of rough colored glass set in H-shaped bars of lead and supported by strong iron bars, soldered to the leading and fastened to the sash. Because the pieces are set in lead such glass is often spoken of as "leaded" glass. The glass used in church windows is also of different qualities, as well as color, the term "stained glass," as commonly used, merely designating art glass set in lead. Thus the common colored glass is called *cathedral* glass; a better glass, somewhat resembling it, but giving richer tones, is called Venetian, and the thick iridescent glass is called *opalescent*. It is by the use of opalescent glass, with its wonderful glow of color and great depth of tone, that the finest results are obtained.

The cheaper grades of windows are made up mostly of cathedral glass, with a few bands of opalescent glass. In the better grades Venetian glass is used for the ground work of the windows and the design is worked out in opalescent glass. A few windows are made up entirely of opalescent glass.

There is nothing about a church that requires more

artistic ability than the working out of the windows, as its successful accomplishment depends not only upon the design, but also upon the ability of the worker to select such colors and thicknesses as will give the desired effect under the particular light to which it will be exposed. One cannot, therefore, expect to obtain an artistic window from a worker who lacks the necessary artistic ability, no matter how great may be his resources in other respects.

The *cost* of stained glass windows depends principally upon the amount and *character* of the labor required in making them, although in geometrical windows the quality of the glass also influences the cost.

Geometrical work and designs not involving figures or emblems are generally estimated by the square foot, the cost varying from 50 cents per square foot for very plain work to $1 for fairly ornamental work, and $3 for very good ornamental work.

Figure work and special designs are estimated by the piece or window.

In placing a contract for leaded glass it is better to refer to some existing window as a basis rather than to colored designs, as the actual window often looks very different from the idea created by the sketch or lithograph. Building committees should be guided largely in the selection of the glass, and, in fact, in all artistic matters, by the advice of their architect.

Fig. 31 is given to show the American method of working opalescent glass into a pictorial window. The lower part of the window is a dull yellow and occupied by figures of the disciples viewing the ascension of Christ. In the right and left panels are angels in flight, signifying the glorification of Christ. The central figure, the Christ, is in the act of ascension, and the glass is so arranged that a halo of light seems to surround the entire body. The notable feature in this window is the fact that all the draperies of the figures and wings of the angels, etc., are so modeled that the varying thickness of the glass produces the light and shade necessary to develop the drawing and folds of the garments. No parts of the window are painted except the head, hands and feet of the figures. The color, starting with a dull yellow at the base, and the glass composed of blue and yellow, making the atmospheric surroundings to the figure of Christ, gradually runs into an orange and finally into a deep red at the top of the window. A glorious effect of color is thus obtained.

There are several methods of making these figure windows for churches. First, by the American method of using the natural effects of the glass to produce the

picture; second, by first selecting the glass of the colors desired and then painting each piece to produce the finished picture. This last is the European method, and it is superior in some respects to the American method where strong light is not to be obtained. A very good combination can be made by making the ornamental part or frame for the picture of opalescent glass and painting the entire inner panel or picture upon the glass.

CHAPTER VI.

DETAILS OF CONSTRUCTION.

FOUNDATION, WALLS, FLOORS, GALLERIES, ROOFS, SPIRES, WINDOWS AND DOORS. MISCELLANEOUS SUGGESTIONS.

THE materials used in the erection of a church are the same as those used in other buildings, and the principles involved in the construction and in the proper use of the materials are the same for all buildings, so that any treatise on building construction applies as well to the construction of a church as to any other edifice. The purpose of this chapter is not, therefore, to describe the various operations required to erect the building, as these have been fully and sufficiently described in other works, but rather to call attention to certain features which are not commonly found in other buildings, and to certain details that are peculiar to churches. A very important principle to be considered when preparing the plans and specifications is to build so that there will be the minimum necessity for repairs. It is a well-known fact that the average church building is not as well cared for as private buildings, and hence the construction, particularly on the exterior, should be adapted to withstanding the elements for a long time without repairs or special attention.

Foundations. A good and substantial foundation is of the first importance for any large building, and especially so for a church. The window openings in a church are usually much larger than in secular buildings, and the walls cannot be as well braced as in buildings having floor beams every ten or twelve feet in the height, and for these reasons any settlement of the foundation will affect the walls more than in most other buildings. Moreover, while cracks are unsightly in any building, they are particularly so in a church, where the large expanse of decorated wall surface of the interior renders them very conspicuous.

A part of the foundation which should be especially looked after is the footing course and also the nature of the soil on which it rests. Whenever possible the footings should be carried to firm soil and always below frost line, and for large brick or stone churches the author recommends that they be made of Portland cement concrete mixed in the proportion of one part of cement to two of sand and four of broken stone or coarse gravel. The footing should always project equally on each side

[illegible] [illegible]

In a church there is usually a great variation in the height of the wall at different places in the building, and especially where the tower joins the main walls. This variation in height produces a corresponding variation in the pressure on the footings, and to avoid unequal settlement of the walls the width of the footings should be proportioned so that the pressure per square foot on the soil will be practically uniform under all portions of the building. The best way in which to do this is usually to decide on the proper width of footings for the main wall; then determine the pressure per square foot which it will impose on the soil, and, using this as the unit pressure, proportion the width of the footing under the tower walls, piers and lower walls to give the same unit pressure. A portion of the walls that is very apt to crack from settlement is that under a wide window, and especially when the sill of the window is but a few feet above the footing. In such cases there will be a considerable pressure on the [illegible] than those under the walls at each side, and even then it is not always possible to prevent a small crack. If the basement is to be finished, the outside of the foundation

Walls. These, if of brick or stone, should be of ample thickness, well bonded together and slushed with mortar. It should be remembered that a high and long wall needs to be thicker than one that is frequently braced by floors and partitions, and in the average church the roof construction usually imposes a considerable weight on the wall, and often a slight outward thrust. Brick walls over 14 ft. high, and not braced by frequent buttresses (See Fig. 32) should not be less than 16 ins. thick, and no wall should be less than 12 ins. thick. When the building is roofed with trusses of the hammer beam type, it is almost necessary to place buttresses against the walls, opposite the trusses, and with any type of truss a wall may be made more stable, with the same amount of material, by the use of buttresses, and a thin wall between, than by making the wall of a uniform thickness. In long and narrow buildings with high walls there is also danger of collapse from wind pressure unless the walls are well braced, and for such buildings it is very desirable to break the side walls by shallow transepts, as at A, Fig. 33, as the sides of the transepts act to stiffen the wall and to prevent the building from racking sideways.

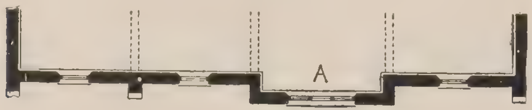


Fig. 33.

Stone Trimmings. The amount of stone trimmings used in a brick or stone church will depend in a great measure upon the architectural style of the building and upon the limit of cost. As a general rule, every piece of cut stone used adds to the cost of the building, but there are certain trimmings that are absolutely necessary, such as the window sills, weathering for buttresses, etc. All stone trimmings having a wash on top or projecting from the wall, should have a drip on the under edge (Fig. 34), so that the water will drop from the stone instead of following along on its surface and down on the wall.

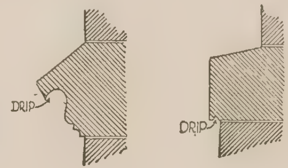


Fig. 34.

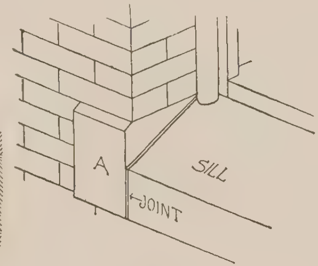


Fig. 35.

Where an effective drip is not provided, the wall is sure to be stained and injured by the water running down over it. In regard to window sills, the author has found it advisable to use slip sills for all windows over four feet wide, to prevent their being cracked by the inevitable settlement of the brickwork in the piers at each side of the window. The appearance of "lugs" may be obtained by building separate pieces of stone (A) in the wall for the sills to abut against as in Fig. 35. For sills less than

Fig. 36.

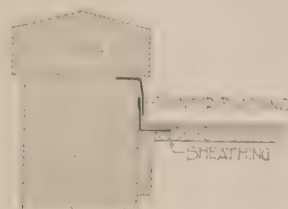


Fig. 37.

4 ft. long it is better to have the lug cut on the sill. Another portion of the trimmings that should be very carefully designed is the coping of the gable walls. For small churches, the author recommends that the roof be extended over the gable walls as in the churches shown on plates XIII.-XVII., for the reason that where the gable walls rise above the roof is a very common place for leaks. For an imposing brick or stone church it is generally considered necessary to extend the gable walls above the roof and terminate them with a stone coping, as shown on plates IX., X. and XXXIII. In designing this coping, two points must be considered aside from the appearance, viz., the prevention of leaks and the stability of the pieces. To make a tight joint where the roof joins the wall, the bottom of the coping should always be at least 6 ins. above the roof sheathing, so that the counter flashing may be

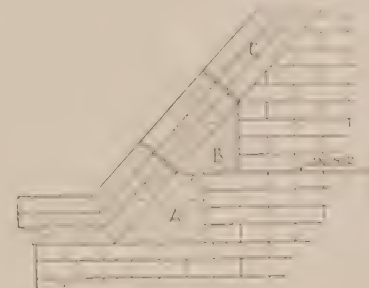


Fig. 38.

built into the joint under the coping, as in Fig. 37, instead of being wedged into a groove cut in the back of the coping.

The other point to be considered is to secure the coping so that it will not slide. If the building fund will permit, it is always much better to cut the coping so that

every piece will have a horizontal bed, as shown at A and B, Fig. 38. As it is expensive to cut the stone in this way, the more common custom is to cut the bricks to the line of the coping, and to set the stone on a slant, as shown at C. When this is done, there is always a tendency for the coping to slide on the wall, and in winter this tendency may be greatly augmented by water collecting in the joints of the coping and freezing, and by its expansion, producing a very considerable thrust on the stone. To resist this tendency of the coping to slide, and the additional action of frost, the two lower pieces should be cut as in Fig. 38, and an anchor 4 or 5 ft. long should be dowelled into the lower stone, and built back into the wall, and at intervals of six or seven feet, short stones like B, should be inserted, and these also should be anchored to the brickwork, so that all of the pressure will not come on the lower stone. There have been many instances of stone coping sliding from the wall for lack of these precautions. When the roof has a rather flat pitch, a pier three or four feet wide may be carried up each side of the gable, to hold the coping, as in the illustration, Plate XI.

Floors. Every part of the church edifice should have ample strength and the floor timbers should be designed to support a load of not less than 80 lbs. per square foot over their entire surface (over and above the weight of the floor itself) and certain portions, such as the floors of the vestibules, and places liable to be crowded, should be proportioned to support a load of 120 lbs. per square foot. Floor joists 14 ins. deep should not be less than 2½ ins. thick, as 2-inch joists are apt to fail by buckling unless bridged every four or five feet by solid bridging, and such bridging will usually cost more than the extra thickness in the joists.

In locating the posts and girders, it should be remembered that it is better and generally more economical to give the longer span to the joists and to limit the girder spans to 12 or 13 ft. for wood and 16 ft. for steel.

Bowled Floors. There are two methods of forming a bowled floor, the choice of one or the other depending principally upon the use that is to be made of the space beneath.

If there is a finished story below the audience room for the Sunday School or parlors, the appearance and utility of the rooms usually demand that the posts supporting the girders shall be as few in number as possible and arranged in parallel rows. With such conditions it will be necessary to frame the floor above for a straight incline, elevating the girders to suit the inclination of the floor, and forming the bowled surface by furring up from the floor joists. The furring strips should be two inches thick and may either be run across the joists or be spiked on top of them lengthways.

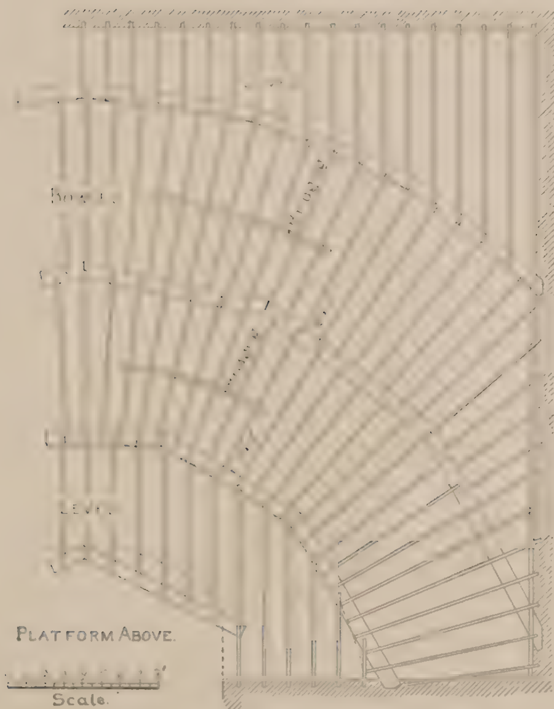


Fig. 39.

When the space beneath the bowled floor is used for such purposes that the position of the piers or vertical supports is not of consequence, the cheapest way to frame the floor is to use short lengths of girders and set them tangent to a circle struck from the center used for the seating plan. Each line of girders will be level, and by raising the different rows to correspond with the inclination of the floor, the joists may be set on top of them in the right position to receive the flooring, and no furring strips will be required. Fig. 39 shows the beams and girders of a bowled floor that was framed in this way. A little fitting of the joists on the girders is required, but the labor and material required for a floor framed in this way will not be more than 20 per cent. greater than for a level floor. When the inclination of the bowl is not more than one-half inch to the foot, the floor boards can be laid in straight lines across the room in the usual way, as the boards will spring sufficiently to fit the floor. The ends of the boards, however, will have to be cut where the bowled surface terminates unless the bowling is very slight.

Gallery Framing. When there is a gallery in a church, the beams are usually supported by the main walls at the outer end and by a partition or posts and girders under the inner edge. Bracket supports are not usually desirable, as it is difficult to give them the necessary

strength. If the gallery has an inclination lengthways, the beams are usually dropped at the back the same as at the front so as to maintain the same inclination from the front to back at all parts of the gallery.

When the conditions will permit, the author has found the method of gallery supports shown in Figs. 40 and 41 to be the most practical and economical.

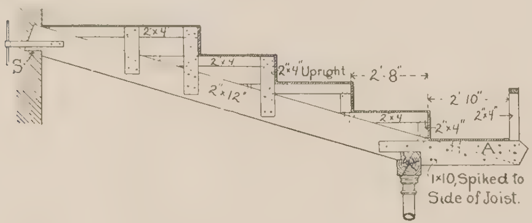


Fig. 40.

The support is obtained by 10, 12 or 14-inch joists, according to the span, which rest on a girder at the inner end and are built into the wall at the outer end. Especial provision should be made to have the joists well tied to the wall, as otherwise the weight will have a tendency to push them inward, or the wall out. At least every other joist should be securely anchored. The wall end of the joists should also be notched, as shown at S, to give a horizontal bearing on the wall.

The steppings may be formed of 2 x 4's, supported by $1\frac{1}{4}$-inch boards, spiked to each side and to the joist, or 2 x 4 uprights may be set under the ends of the horizontal pieces, as shown.

The projecting front, where it does not exceed three feet, may be framed by spiking a wedge-shaped piece of plank to the top of the joist and then nailing a wide board to the side of both pieces. The rail, if of wood, is gen-

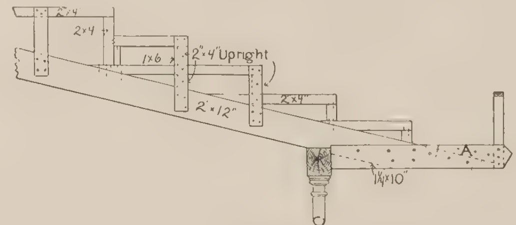


Fig. 41

erally constructed of a framework of 2 x 4's ceiled on the inside and paneled and moulded, as may be desired on the outside, the top being covered with a wide cap piece. The uprights of the framework should be securely spiked to the side of the joists supporting the gallery.

In churches it is not desirable to have the solid portion of the railing exceed 2 feet in height on the inside, and 22 inches is better.

If a higher rail is desired, an ornamental rail of 2-inch brass pipe, with standards from 3 to 4 feet apart,

may be placed on top of the wooden rail, as this does not obstruct the view as a wooden railing would.

If the projection of the gallery front beyond the line of the posts is between 3 and 6 feet, the floor may be supported as shown in Fig. 41. In this case it will be necessary to drop the upper ends of the 12-inch joists so that the inner ends will come about as shown in the figure. In order that the view may not be obstructed more than necessary, the depth of the joists under the front step should not exceed 10 inches and the girder should drop as little as possible consistent with proper framing for the joists.

If the gallery is circular in plan, the joists should radiate toward the center, from which the steppings are described, and the girder should be built of two steel channels bent to the proper curve and breaking joint over alternate supports.

ROOF CONSTRUCTION.

The manner in which a church is roofed has very much to do with both the appearance and the cost of the building, and hence when drawing the plan the facility which it offers for roofing should be constantly kept in mind. If the funds for building the church are very limited, the facility for roofing should to a considerable degree determine the arrangement of the plan.

In nearly every church the roof itself must be supported by trusses, and the design of these trusses is a matter of very serious consideration, as upon them depend the safety of the roof, and to a greater or less degree the appearance of the interior and the cost of the building.

As a rule, the narrower the building, the cheaper it can be roofed, and it is also easier to roof a building with a cruci-form plan than a square or octagonal building of the same floor area, and especially is this true when open timbered construction is to be used.

In drawing the roof construction, the first question to be considered is the general plan of the roof, and next whether the construction shall be exposed or whether there shall be a ceiling below the roof concealing the supports and affording an air space under the roof.

Exposed construction, or open-timbered roofs, as they are generally designated, give the handsomest interior, but they are more expensive and are a source of great loss of heat in winter and they make the building warmer in summer.

Unless the trusses are very simple, it will cost more to finish them and also finish the underside of the roof than to hang a plastered ceiling from the trusses.

Open Timbered Roofs. For this kind of roof construction the rafters and purlins are often dressed and also the underside of the roof boarding, so that the real

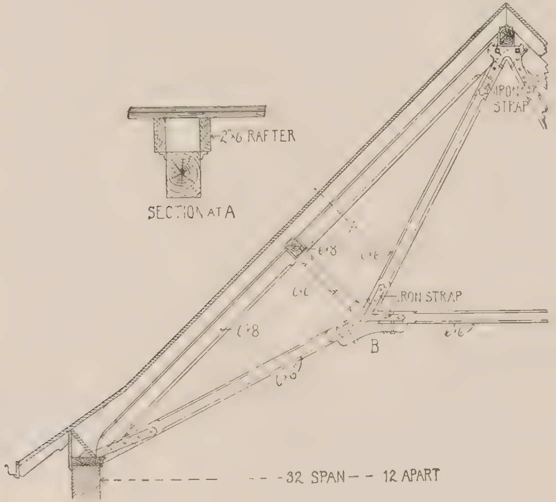


Fig 44.

construction is exposed. This requires regular spacing of the rafters, to give a good effect, heavier timbers and double boarding to prevent the shingle or slate nails from

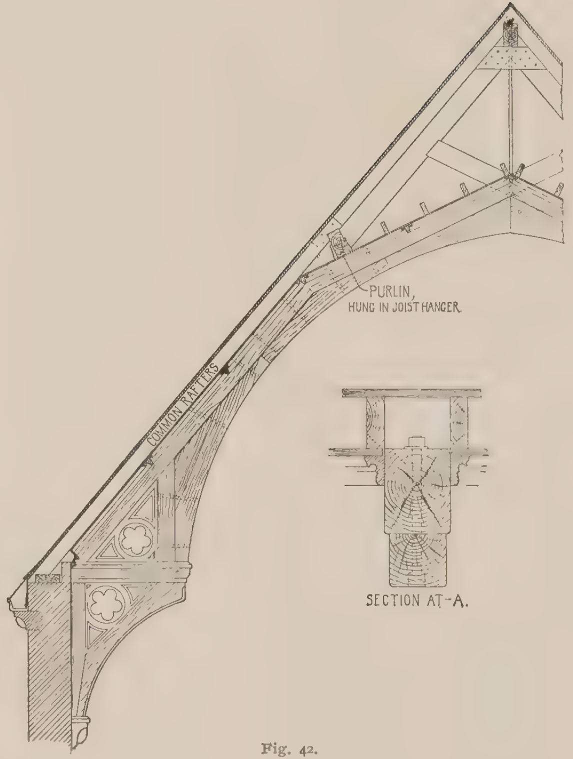
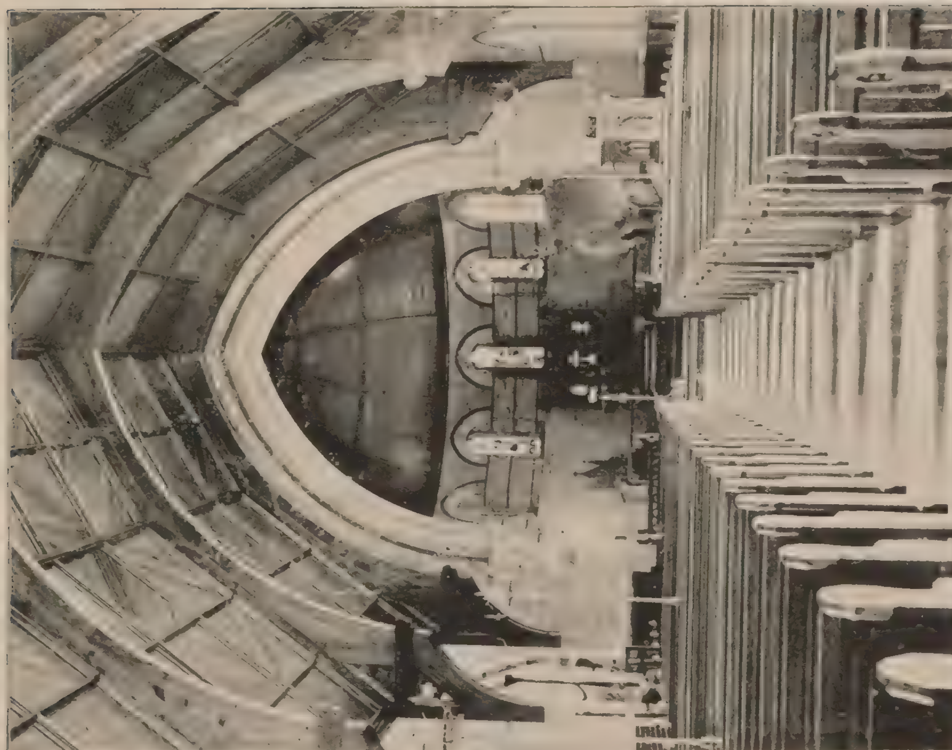


Fig. 42.



INTERIOR OF CHURCH.

C. C. HAUGHT ARCHITECT

going through. The slight thickness of wood separating the audience room from the outer air also permits of a

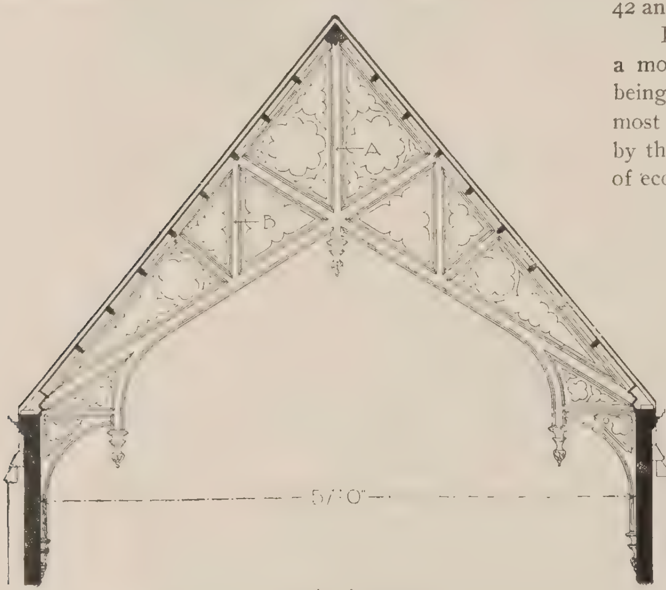


Fig 46.

great loss of heat. The author, therefore, recommends that the rafters be left in the rough and ceiled on the under side or furred and ceiled, and that mouldings be planted on the ceiling to divide it into panels, as shown by Figs. 42 and 43.

In the opinion of the author, this construction gives a more comfortable room and better acoustics, besides being usually cheaper. In regard to the trusses, the shape most desirable will be determined to a considerable extent by the span, the strength of the walls and by the degree of economy that must be practiced.

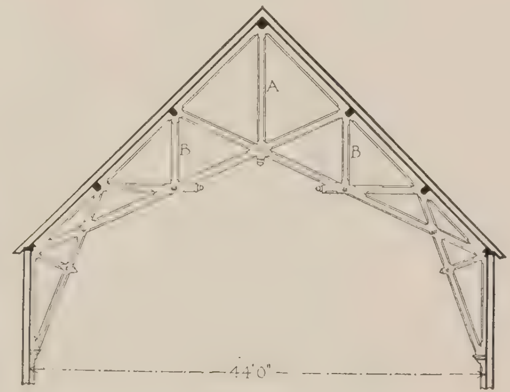


Fig. 45.

For a small church with a width not exceeding 32 ft. inside, a truss like that shown in Fig. 44 is inexpen-

sive and neat in appearance. When properly built it will exert no thrust on the walls. Where something more ornamental is desired, a truss such as is shown by Figs. 42 and 43 may be used. This truss, however, depends upon the transverse strength of the principals and the resistance of the walls to keep it from spreading, and is only suitable

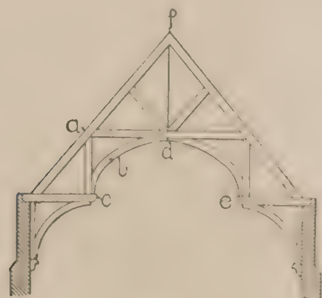


Fig. 47.

for spans of 35 ft. and under. With such a truss, therefore, the walls should be reinforced by buttresses.

For greater spans, a truss of the scissors or hammer beam types may be used.

Fig. 45 shows a scissors truss in about its simplest form, and Fig. 46 shows what is practically the same truss, more elaborately treated, the constructive members being nearly the same in each truss.

Fig. [illegible]

Either of these trusses may be used for spans up to 60 ft., and on either wooden or masonry walls, although the truss shown by Fig. 45 is the best for a wooden building. The pieces A and B should be hollow with a rod inside.

For elaborate open roof construction, some form of the hammer beam truss is more generally used, because

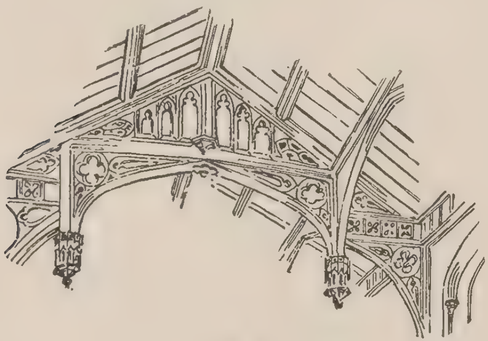


Fig. [illegible]

the arrangement of the pieces is particularly well adapted to decorative treatment.

The typical shape of this truss may be represented by Fig. 47, although one seldom sees two trusses that are exactly alike.

The hammer beam truss was extensively used in England during the fifteenth century for supporting the open timbered roofs of Gothic halls and churches, and has

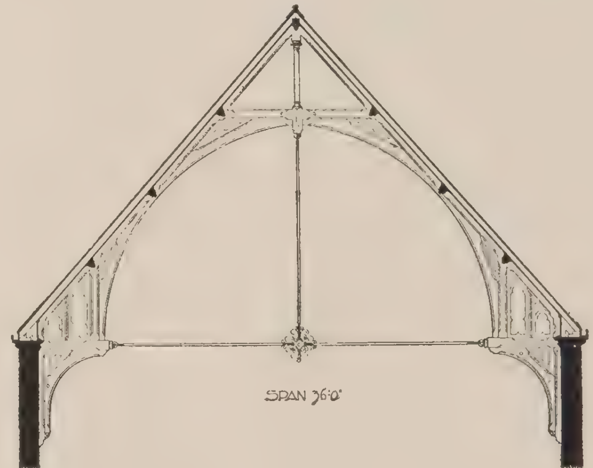


Fig. 50.

been a favorite form of truss for Gothic roofs ever since.

The first truss of this time, it is believed, was used in the great hall of Westminster Palace, built in 1397, an illustration of which is shown in Fig. 48. It is difficult to

improve on the original truss, either in appearance or strength.

Fig. 51 shows an adaptation of the Westminster truss by Messrs. Cady, Berg & See, in the *Church of the Redeemer* at Paterson, N. J. Fig. 49 shows a very pretty hammer beam truss from Christ Church, England, the pitch of the roof being considerably less than is common for Gothic roofs. As usually built, a hammer beam truss will exert a slight outward thrust on the walls, but by means of the curved brackets under the hammer beam, the thrust is applied at a considerable distance below the wall plate, and the direction of the resultant thrust is usually very steep.* The truss should be used only on brick or stone walls, and even these should be reinforced by buttresses. When the walls are high, so that the truss is well elevated, an iron tie rod may be used as shown in Fig. 50, which will prevent any thrust whatever on the walls. The tie rod should extend through the hammer beams to their outer end.

Fig. 52 shows one-half of a hammer beam truss 61 ft. span designed in the office of Messrs. Ware and Van Brunt about twenty-four years ago, and Fig. 53 shows the construction of the same. It will be noticed that an iron rod is concealed in the king post. The curved rib connecting the hammer beam with the bottom of the king rod is in tension.

This rib should be built up to give the greatest possible strength, and should be firmly secured at each end.

In all hammer beam trusses the rafter or principal should be made unusually large, as it has to resist more or less transverse strain.

Fig. 54 shows a modification of the hammer beam truss which is very strong at the top, but depends upon the transverse strength at A A and the resistance of the walls to keep it from spreading. This particular truss has a span of 50 ft.

When the church has a transept of the same width as the nave, the roof over the square formed by the intersection of the two and designated as the "crossing," must be roofed either by diagonal trusses, as shown in Fig. 51, or by trussed valley rafters, as shown in Fig. 55. For open diagonal trusses, some truss with a center rod will be found best adapted, both to the construction and to the ornamental effect.

Very often, however, the valley timbers themselves may be given sufficient transverse strength to support the roof, the walls at the angles being usually capable of resisting any thrust that may come upon them. A very good and practical method of roofing a large rectangular

* The mechanical principle of the Hammer Beam Truss is explained in the *Architects' and Builders' Pocket Book.*

CHURCH OF THE REDEEMER.

Fig. 51. CADY, BERG & SEE, ARCHITECTS.


HAMMER BEAM TRUSS
FIRST CHURCH, BOSTON,
K

Fig. 52.

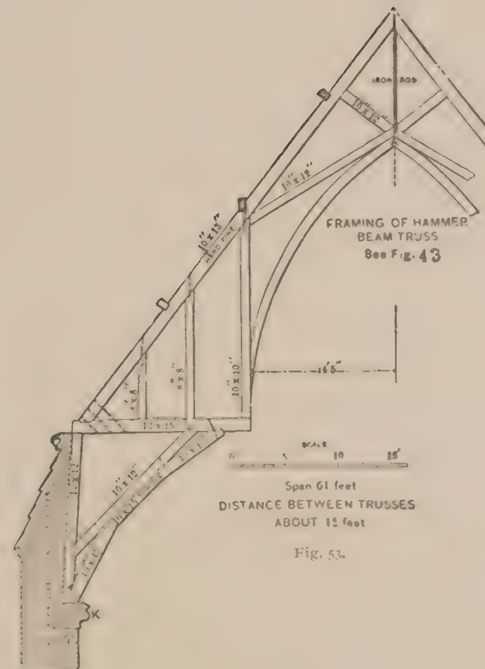

IRON ROD
FRAMING OF HAMMER
BEAM TRUSS
See Fig. 43
SCALE
10
15
Span 61 feet
DISTANCE BETWEEN TRUSSES
ABOUT 15 feet
K

Fig. 53.

church by means of trusses of moderate span and at the same time have but two posts in the body of the church, is shown by Figs. 55 and 56. The plan is particularly well adapted to Episcopal churches, as it gives the appearance of nave transept and aisles, and at the same time a well-shaped room for hearing and seeing. By bolting the ends

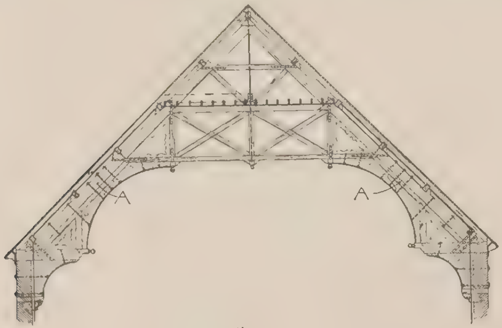


Fig. 54.

of the trusses together where they meet on the columns or piers, a sort of hollow square is formed to receive the thrust of the valley timbers, and the horizontal trusses A and B, reinforced by the outside walls and buttresses offer additional resistance.

In the church shown by Fig. 55, the choir piers are connected with the main walls by stone arches, which were necessary to resist the thrust of the choir arch. Where columns are used to support trusses, their tops should al-

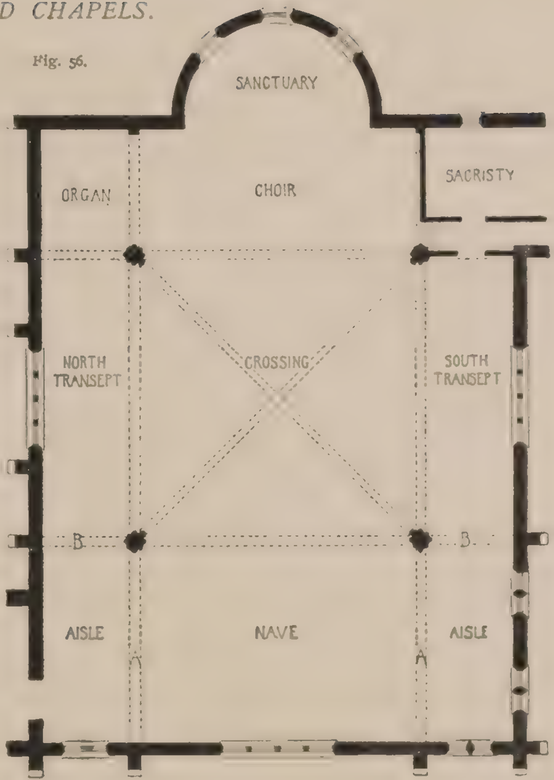
ST. STEPHENS CHURCH, LYNN, MASS.
Fig. 55. WARE & VAN BRUNT, ARCHITECTS.

ways be rigidly braced, both longitudinally and trans-

versely, either by short horizontal trusses or by heavy beams.

The arrangement shown by the plan, Fig. 56, is also well adapted to roofs with suspended ceilings and concealed trusses.

Fig. 56.



ROOFS WITH SUSPENDED CEILINGS.

Owing to the greater cost of the trusses and finish of open timbered roofs, and the additional cost of heating the building, most modern churches have suspended ceilings supported from the tie beams of the trusses, which conceal all of the constructional features.

The ceilings, however, are generally raised in the center, and are often domed or vaulted; they may be finished with wood, metal or plaster, the last mentioned material being the most common. Occasionally a portion of the truss is exposed beneath the ceiling, and the latter is paneled to give the appearance of an open timbered roof, as shown in perspective in Fig. 57 and in section in Fig. 58. Such construction is usually much cheaper than true open timbered construction, and in small churches nearly as effective, and it has the advantage that the roof can be constructed so as to have no horizontal thrust, thus permitting of lighter walls; or, if necessary, of frame walls, besides making the room easier to heat and ventilate.

A very economical and quite pleasing roof construction for a small chapel is shown by Fig. 59. The truss is a simple scissors truss with only one purlin on each side. Ceiling joists extend across the roof from purlin to purlin, and below the purlins the laths are nailed to the underside of the rafters. The tie beams are cased, and also the lower part of the principals, and the portion of the center rod below the ceiling is boxed to give the effect of an open timber truss. False collar beams, A, are also built to finish the trusses at the ceiling line. This is a very strong truss up to 30 ft. span, and may be safely used on wooden walls.

Most churches from 30 to 40 ft. wide, however, have the ceiling built with an outline similar to that shown in Fig. 60, as it is about the cheapest to construct and gives the desired height, and a fairly good surface for decoration. Occasionally a curved outline is given to the ceiling.

For such roofs the scissors truss is best adapted, as its outlines correspond with those of the roof section. When the span of such a roof does not exceed 35 ft. the roof and ceiling may be economically constructed by spacing the rafters from 28 to 32 ins. on centers and trussing each pair of rafters, as shown by Fig. 61. By this method no purlins are required, and very little iron work and the amount of timber in the roof will not much exceed that in an ordinary roof without trusses. It also has the advantage that the weight is evenly distributed over the walls.

If the ceiling is of wood, it may be nailed directly to the under side of the trusses; if of plaster, the laths are

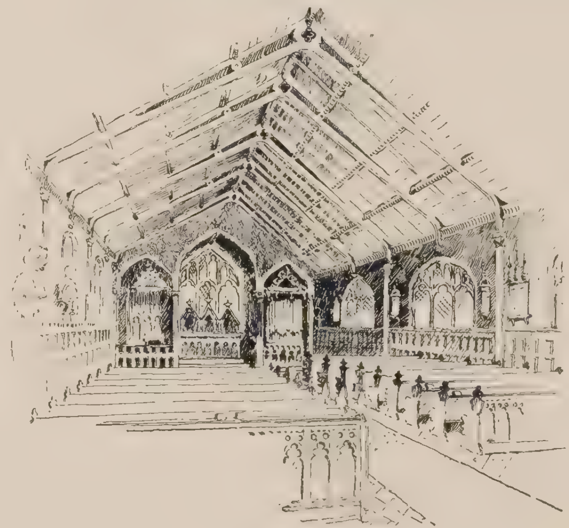


Fig 57

nailed to furring strips or strapping fastened to the underside of the tie and collar beams. The author has adopted

this method of roofing in two or three churches with good results. It is not, however, a desirable method of con-

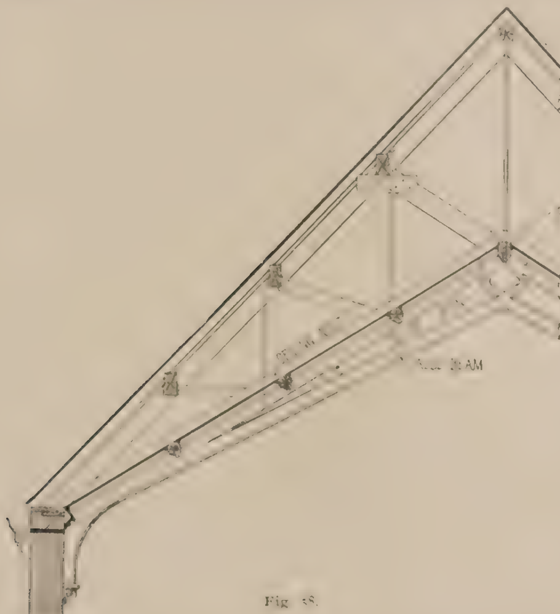


Fig. 58.

struction when there are side gables or dormers. In constructing trusses of the scissors type, the author has found it best, under ordinary conditions, to build the tie beams and rafters out of planks bolted together, giving the tie beams a section about double that determined by calculation. By this method of construction it is easier to make good connections at the intersections and not as much iron work is required. It is also often difficult to obtain large timbers that are well seasoned, and especially timbers that will be long enough for the tie beams, without splicing, and if the timbers must be spliced, it is much better to use planks, except, perhaps in the case of very heavy trusses. In the church shown on Plate XVII., the trusses are of the shape and dimensions shown by Fig. 62, and were built up of 1-inch boards spiked together, each layer being spiked separately to the next. As the church was built in a country town, the saving over large timbers and iron rods was quite considerable.

The only objection to the use of thin stuff is that in seasoning in the building, the outer boards are apt to curl and separate from the inner ones, and for this reason it is desirable that a few bolts be used to hold them more securely in place. Wooden ties, especially in the center, are also not as desirable as rods, as there is no way of tightening them; they are also dangerous in case of fire.

In building up the tie beams, pains should be taken to see that enough long pieces are used to carry the entire

tensile strain, or in case planks of sufficient length cannot be obtained, to splice them so as to give the necessary tensile strength.

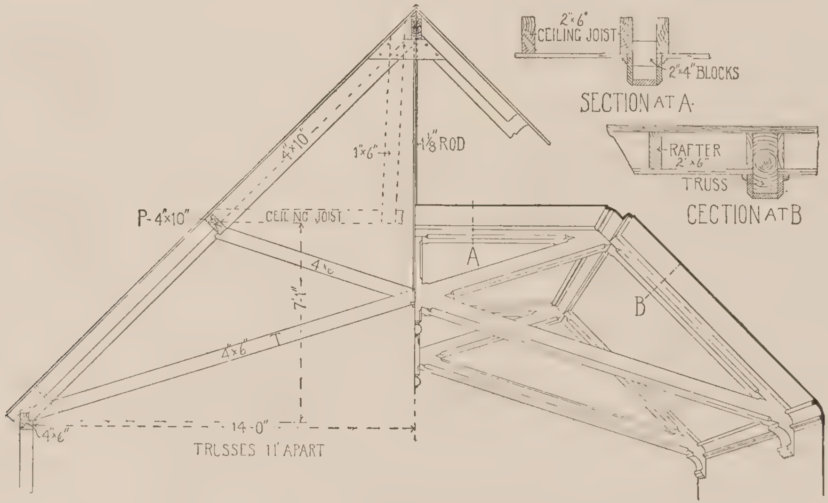


Fig. 59.

Fig. 63 shows one of the trusses used in the roof of the chruch shown on Plate XXVI., and Fig. 64 shows the diagonal trusses used for supporting the central portion of the roof. In this church the ceiling joists were supported by ceiling purlins, corresponding with the roof purlins, and extending from truss to truss. The advantage of this arrangement is that no transverse strain is brought on the tie beams, and they can therefore be of smaller dimensions than if the ceiling joists rested on

them. A little less weight is also put on the truss when the purlins are used.

Instead of making two diagonal trusses of the same size and strength, one truss (truss A, Fig. 64) was made strong enough to carry the entire load, and two half trusses were substituted for the other truss. These half trusses (which are really complete trusses in themselves) are supported at the center of the through truss by means

Fig. 60.

of a heavy double stirrup which passes over the top of truss A and is long enough to receive the tie beams of the half trusses. Iron tie plates were bolted to the tie beams of the half trusses to prevent their pulling out of the stirrup iron. The reason for this construction was the difficulty of splicing the tie beam where two intersecting trusses of equal strength are used. In this instance the method employed seemed to be the simplest and as cheap as any.

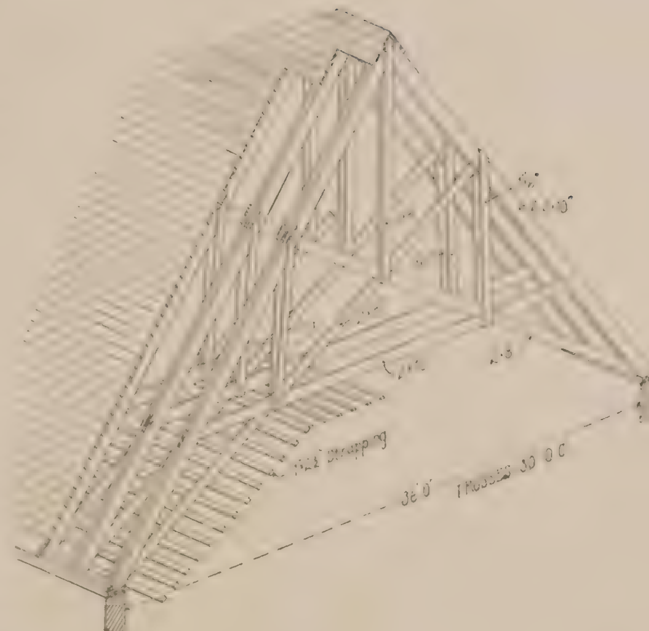


Fig. 61.

ROOFING BY MEANS OF LONGITUDINAL TRUSSES.

When the plan of the audience room is similar to the plans shown on Plates XXXVI. and LII., and the side gables, if any, are comparatively narrow, the roof and

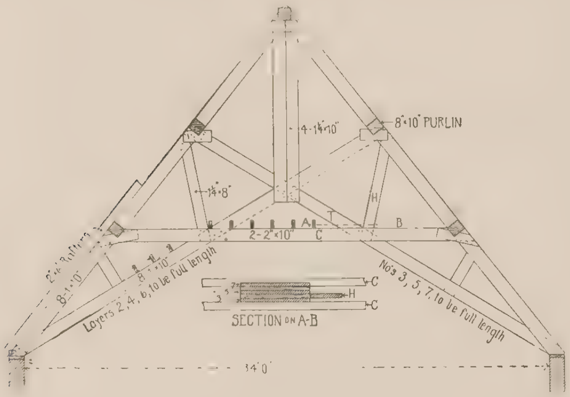


Fig. 62.

ceiling can often be best supported by means of two horizontal trusses placed longitudinally of the roof and supporting small transverse trusses, if necessary. The author has used this method of construction a number of times with economical and satisfactory results. Fig. 65 has been drawn to illustrate this method of construction; it also shows the roof and ceiling construction of the church shown on Plate XXXVI., and by the interior drawing, Fig. 66.

The ceiling is of lath and plaster, and is divided into panels by false beams, as shown by the interior sketch. The general shape of the ceiling is also shown by the heavy line, Fig. 65. The width of the audience room between walls is 56 ft. 8 ins., and the clear span of the horizontal trusses 51 ft. 8 ins. The width of the gabled recesses at the sides is 17 ft. As shown by Fig. 65, the roof and ceiling are supported primarily by two Howe trusses, placed as indicated by the dotted lines on the second floor plan. The top chords of these trusses serve as one of the purlins on each side of the roof to support the rafters, and the lower chords support the outer ceiling beams. To support the ceiling joists and rafters over the space between the Howe trusses, four smaller trusses, C, were placed across the space with their ends resting on the top chords of the longitudinal trusses. The tie beams of these transverse trusses support the ceiling joists and the top chords support another set of purlins. The tie beams of the transverse trusses drop below the ceiling joists, and are cased to correspond with the false beams used in dividing the ceiling. From an inspection of Fig.

65 it will be seen that about four-fifths of the entire roof and ceiling are supported by the two Howe trusses, L L.

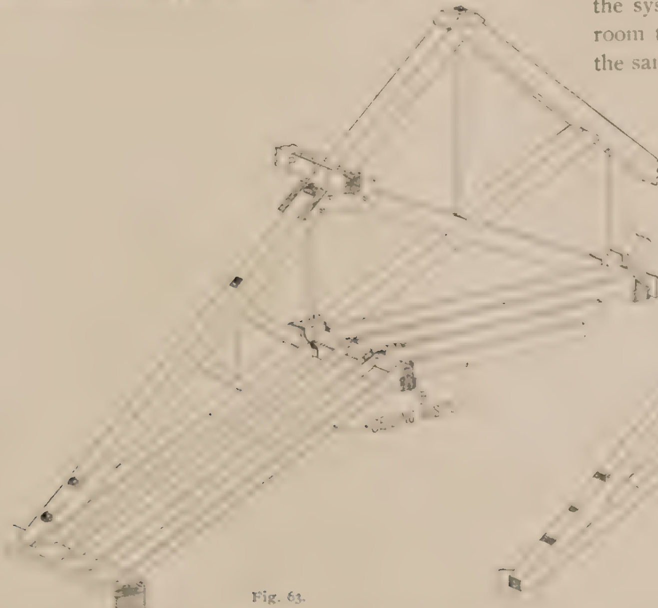


Fig. 63.

and these again are supported by three wooden posts (marked P on the plan), and by the inner angle of the tower, hence but very little weight comes on the walls.

The advantages of this system of roofing are: First, the system gives a greater clear height for the audience room than can be obtained with transverse trusses with the same height of walls.

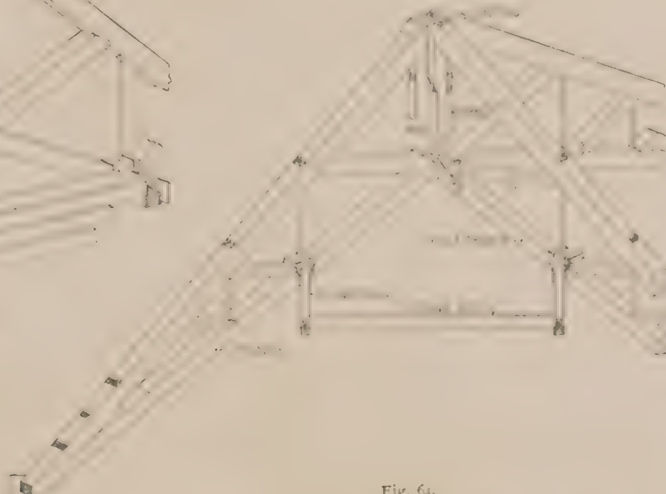


Fig. 64.

Second, the shape of ceiling naturally adapted to this system of roofing seems appropriate and fitting to the plan.

Third, by this system no thrust is exerted on the outside walls, and but little weight, while the rigidity and weight of the center roof and ceiling really tend to stiffen the walls and to prevent the building from racking sideways.

Fourth, economy. Trusses with horizontal chords are the simplest and easiest to construct, and where they are adapted to the shape of the roof, require the least amount of material. And not only are the trusses themselves such as any carpenter can easily construct, but the general construction is easily erected and can be put up before the side walls are completed, thus advancing the completion of the building.

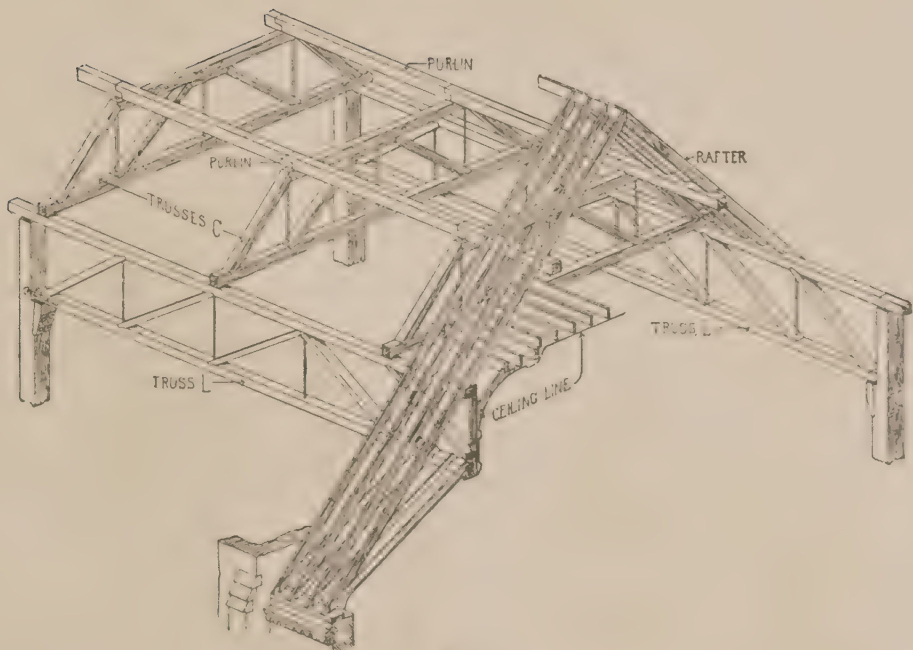
As soon as the transverse trusses are in place, the center ceiling joists may be set, and thus a convenient permanent stage is provided for the use of workmen while completing the roof. This system is as well adapted to a wooden as to a brick church, and can be used over rooms up to 100 ft. in depth and 80 ft. in width, provided that the pitch of the roof is 45 degrees or more. The height of the Howe trusses should never be less than one-eighth of the span, and should be made one-sixth of the span, if possible.

Vaulted Ceilings. When the ceiling is in the shape of a barrel vault, the system of longitudinal trussing will often be the only one that can be employed. Fig. 67 shows the application of the system to a high vaulted roof, the trusses supporting the upper vault having exposed tie beams and king post.

The roof and ceiling of Emanuel Temple, Denver, illustrated on Plates LI. and LII., are also supported by longitudinal trusses, with cross trusses of the scissors type every 4 ft. apart to support the barrel vault.

The vaulted ceiling shown by the interior view on Plate XLI. and in plan on Plate XL. is supported by trusses at the four sides of the crossing, by trussed purlins and by very heavy valley rafters. The plan of the roof being a Greek cross, with arms about 20 ft. long and solid walls at the angles, it was considered perfectly safe to trust to the walls to resist the thrust of the valley rafters, and they were, therefore, made large enough to carry the weight of the roof over the crossing as inclined beams. The roof and ceiling over the arms are supported by trusses of the pattern shown by Fig. 68, two trusses like this, 6 ins. apart, being placed at each side of the crossing, or directly above the gallery rail. Fig. 69 shows the manner in which the ceiling was formed between the trusses and gables.

The rafters and ceiling ribs or furring are supported by a trussed purlin on each side of the truss which is built into the gable wall at the outer end, rests on the tie beam


PURLIN
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RAFTER
TRUSSES C
TRUSS L
TRUSS L
CEILING LINE

Fig. 66.

of the truss and projects beyond the truss like a cantilever to support the pendentive angles of the vaulting, as shown by Fig. 70.

These purlins meet at the valley rafters, and are bolted together and to the valley as shown by the plan at A. The ribs of the vault at the intersection are supported at their lower end by a built-up diagonal rib, corresponding to the valley rafter of a roof, and this is supported by the bottom chords of the trussed purlins, which are hung by ⅞-inch rods from the top, the purlins being trussed to act as cantilevers. This method of supporting the crossing is often applicable when the ceiling has a different shape from that shown.

CHURCHES WITH HORIZONTAL CEILINGS.

When it is practicable to have a level or paneled ceiling, such ceilings will usually be found much simpler to construct, as trusses with level tie beams can then be used, and such trusses are always more economical than trusses with inclined ties. When there is a large space to be covered, a much simpler form of construction or arrangement of the trusses can also be employed, as part of the trusses can be supported by other trusses, if necessary, and only the simpler types of trusses need be employed.

Steel Trusses. Until within the past twelve years iron or steel trusses were seldom used in churches on account of the expense, but with the decreased cost of steel shapes it is now often possible to use steel trusses at a

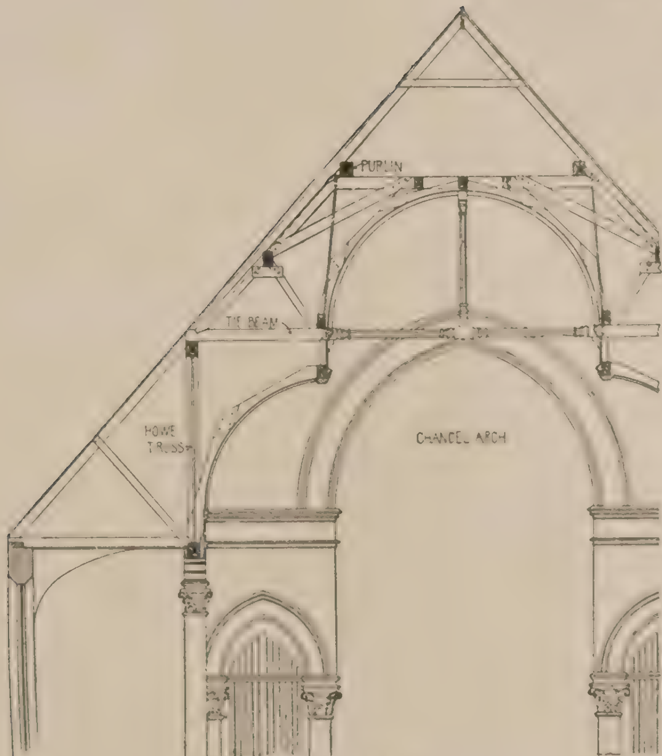


Fig. [illegible]

slight advance in cost over wooden ones, especially where the trusses have a wide span and inclined ties. Unless fireproofed, steel trusses offer no greater protection from fire than wooden trusses, as the steel will twist and bend under heat so as to destroy the roof. Steel trusses, however, can be designed with greater certainty as to their strength than wooden trusses, and it is easier to get the desired strength in the joints.

FRAMED SPIRES.

A tall spire in a gale of wind is very much like a cantilever set upright, and the principles involved in its construction are the same as those upon which trusses are designed, except that with a spire the destructive force acts horizontally instead of vertically.

A framed spire may fail in either one of two ways: Fig. 71 represents a spire which is strong enough in itself, but which, on account of not being anchored to its foundation, is being overturned and pushed off the tower.

Fig. 72 represents a spire which is sufficiently anchored but insufficiently braced.

Fig. 73 represents the tendency of the wind pressure on the spire to rack the tower. In this case failure occurs in the tower and not in the spire.

Of course, a tower and spire may be weak in all three

directions, but actual failure will usually occur in one of the ways above illustrated.

Resistance to Overturning. In a spire whose height is not greater than twice the width of its base, the weight of the framework and covering will generally be sufficient to prevent its overturning, although all spires should be bolted to the walls to some extent, for the purpose of strengthening the wall and overcoming the tendency to slide.

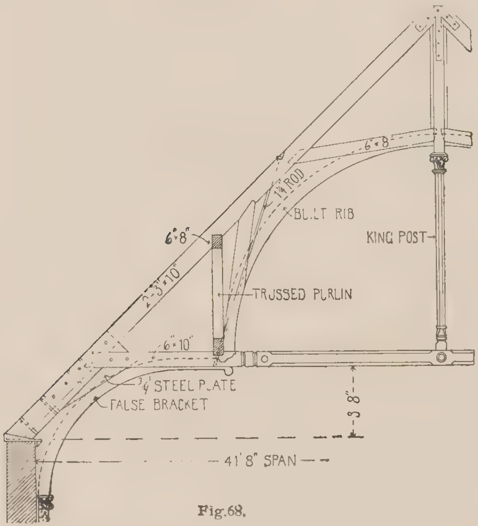


Fig. 68.

When the height of a spire exceeds two and one-half times the width of its base, it will generally be necessary to depend upon rods or bolts carried well down in

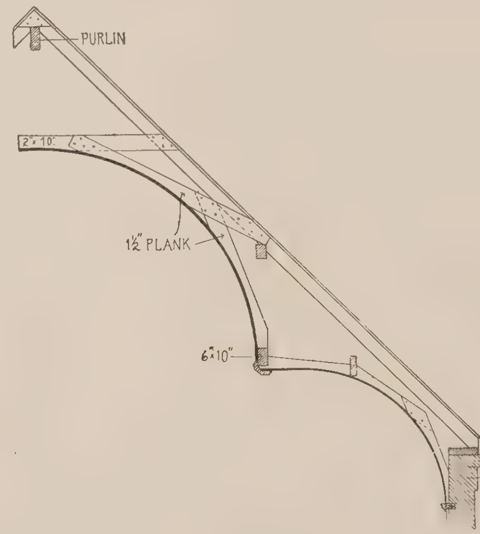


Fig. 69.

[illegible]

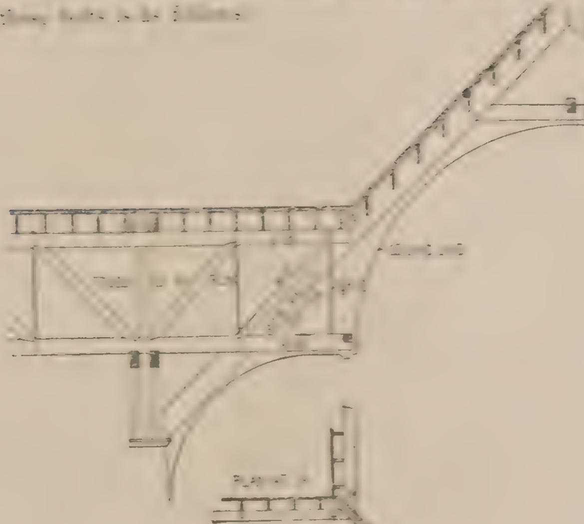


Fig. 70.

[illegible]

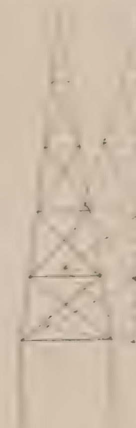


Fig. 71.

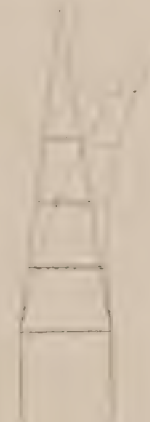


Fig. 72.

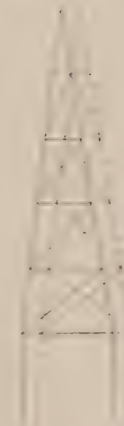


Fig. 73.

tendency is in part resisted by the weight of the framework and roof covering, which act through the center of [illegible]

[illegible]

entire windward side of the spire, multiplied by the pressure per square foot.

In calculating the wind pressure on roofs it is customary to assume 40 pounds as the maximum horizontal pressure per square foot.

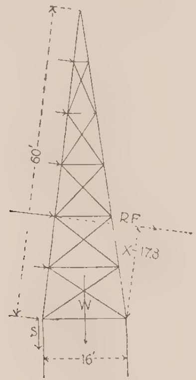


Fig. 74.

As spires, however, are usually exposed to the full force of the wind, the writer recommends that 50 pounds be used as the normal wind pressure on spires having a pitch exceeding 60 degrees.

The area of one side of the spire shown in Fig. 74 = 480 square feet. Multiplying this by 50 we have 24,000 pounds, as the total wind pressure on the spire.

The resultant of this pressure acts through the center of gravity of the side, which in a triangle is at one-third the height, measured from the base or in this case, 20 ft. As wind pressure is always considered to act at right angles to the surface against which it blows, the resultant will act in the direction of the line R F, and will have a moment equal to the whole wind pressure multiplied by the arm X. The distance X in the figure measures 17.8 feet. The moment tending to overturn the spire will therefore be 24,000 + 17.8 = 427,200 foot pounds.

The weight of the framework, if of wood, will be about 10 pounds per square foot of surface, and the sheathing and shingles will weigh about 5 pounds more, giving a total of 15 pounds per superficial foot for a wooden spire covered with shingles. If covered with slate the weight may be taken at 18 pounds.

Assuming that the spire under consideration is covered with shingles, we will have for the total weight 4 x 480 x 15 = 28,800 pounds. Its resultant will act through the center of the base, and will therefore have a moment about the point (1) = 28,800 x 8 = 232,400 foot pounds. This moment acts in the opposite direction from that produced by the wind, and hence should be subtracted from it: 427,200—232,400=194,800 foot pounds.

The difference between these two moments represents

the force which must be resisted by the anchors on the windward side, as at S. These rods will act with an arm equal to the width of the base, in this case 16 ft. and we should therefore divide 194,800 by 16 to get the stress on the rods at S. Performing the division we have 12,175 pounds as the upward pull on the rods. If two rods are used we will have 6,087 pounds stress on each rod, which will require a diameter of 1 inch if the rod is not upset.

To hold the rods there must be a weight of masonry on the windward side = 12,175 pounds, or about 110 cubic feet. If the wall is 16 inches thick the rods must be imbedded at least 5 feet.

By studying Fig. 74, it will be seen that the wind moment increases with the relative height of the spire much faster than the weight moment, as the arm of the latter remains constant for a given width of the base, while the former increases with the height, due to the raising of the center of gravity of the side and the diminishing of the angle of the resultant with a horizontal line.

Thus, if the length of the rafter in the above example were reduced to 39 ft., keeping the same width of base, we would have 150,540 for the wind moment and 149,760 for the weight moment. And by taking off 1 foot more the spire would be just about in equilibrium. As the wind often acts with considerable impact, however, there should always be some excess of safety.

It will also be seen from the above that the stability is increased by adding to the weight of the tower. Thus, in the case above, where the rafters were 39 ft. long, if the roof were covered with slate, the additional weight would increase the weight moment to 179,712, or considerably in excess of the wind moment.

In an old English spire, which swayed more than was thought safe, a heavy timber was suspended inside from the top, with apparently beneficial effect.

On an octagonal tower the wind pressure is assumed to act against a surface equal to the verticle section taken through the center of the spire, so that the uplift on the windward side is the same as for a square spire.

Effect on the Tower. As shown by Fig. 73, the effect produced on the tower by the wind pressure on the spire is a tendency to rack the tower sideways; this tendency is also increased by the wind blowing against the tower itself. As a rule, towers which support a spire have at least two sides built into the building of which the tower forms a part, so that the leeward side of the tower is well braced, at least to the height of the main walls. If the tower is of frame construction the walls should be braced in a similar manner to that hereafter described for

the spire, at least down to the height of the main walls, and all the uprights should be spliced so as to resist tension, that the ties connecting the spire frame with the walls may draw on the entire weight of the tower.

In brick or stone towers the bonding of the side walls is generally depended upon to resist the tendency to rack. Whenever the height of a spire exceeds 40 ft. the upper portion of the tower walls should be at least 16 ins. thick, unless the corners are strengthened by heavy buttresses.

Another tendency resulting from the wind pressure on the spire is to lift the top of the tower on the windward side, and in a masonry tower to break and crack the masonry near the top. Very often the top of the tower is so slight, owing to the architectural treatment, that it cannot be depended upon to resist the strains from the spire, and braces must be carried down below the upper openings. Examples of such construction are shown in Figs. 76 and 77. Sometimes a square framework is built inside the walls of the tower, with the lower timbers extended into the walls and the spire supported from this framework.

Bracing the Spire. The strains in a spire may be accurately determined in the same manner as those in a truss, and the size of the braces proportioned accordingly. Generally, however, the braces are made larger and more are used than would be determined by theoretical analysis, practical judgment being as important as theoretical analysis, but it is not always safe to depend upon the former alone. When there is a lack of theoretical knowledge, material is generally used unwisely, too much being often used in some places and not enough in others. The method of determining the stresses in a framed spire cannot well be described here, but the correct method of bracing a spire is shown by Figs. 75 and 77.

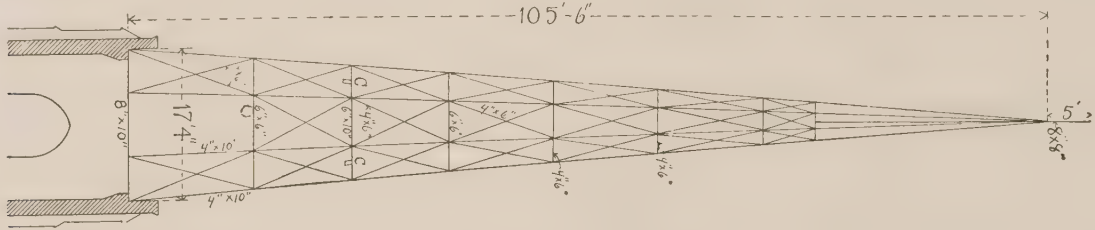


Fig. 75.

Examples of Spire Framing. Fig. 75 shows the framework of the spire shown on page 5. This spire is 111 ft. 6 ins. high above the plate, and the latter is 69 ft. above the sidewalk. The total height from sidewalk to top of finial is 190 ft. The tower is of stone, 19 ft. square, with buttresses as shown. The spire is a true octagon in section, and each of the eight sides is braced in the same way, with the exception of the lower panel, in which the bracing is omitted on four sides back of the dormers. Besides the bracing shown in Fig. 75, the spire was braced across horizontally at each purlin to prevent distortion in the octagon. At the top the eight hips are cut against a 10-inch octagon pole and bolted to it in pairs. This pole is 32 ft. long and is secured at the bottom by bolting to 4 x 6 cross pieces which are securely spiked to the hips. In the center of this pole is a 1½-inch iron rod, which forms the center of the wrought iron finial.

The lower end of each hip is secured to the masonry by 1½-inch bolts, 6 ft. long. The plate extends the full length of each side of the tower and is bolted together and to the walls at the corners. A short piece of 6 x 6 timber is placed on top of the plate, across the corners, to receive the rafters on the corner sides of the octagon. The braces and purlins are set in 4 ins. from the outer face of the hips to allow for placing 2 x 4 jack rafters outside of them. These rafters are not shown in the figure; they were placed up and down 16 inches on centers, and spiked to the purlins and braces.

As may be seen from the engraving, the top of the tower is rather light for supporting such a high framework, and is moreover weakened by large openings in each side. It was therefore determined to transfer the thrust due to the wind pressure on the spire to the corner of the tower at a point just below the sill of the large openings. The manner in which this was done is shown by Fig. 76, which is a diagonal section through the top of tower. The purlins C, C, Fig. 75, were made 6 x 10 ins., set on edge and securely bolted to the hips. From the center of these purlins on each of the four corner sides 6 x 10-inch posts were carried down into the tower, as shown in Fig. 76. These posts were secured at the bottom to 10 x 10-inch timbers which were placed across the tower diagonally and solidly built into the corners. The bracing shown was used merely to prevent the posts from buckling. Only one pair of posts is shown in the figure. The effect of these posts is to transmit the entire wind pressure on the leeward side of the tower from the purlins C, C to the corners of the tower at the bottom of the posts. The tension on the windward side is resisted by the hip rafters and the bolts by which they are anchored to the wall. This spire has stood for ten years, and no cracks have as yet appeared in the tower, although the 1½-inch rod in the

wrought iron finial was slightly bent during a severe gale.

Fig. 77 shows the framing of a smaller spire, designed by the author, in which a similar method was used for transferring the thrust to a point about 8 ft. below the plate. In this case the spire was square, and the posts were bolted to the inside of the hip rafters. At the bottom the posts rest on short pieces of 8 x 8 timbers, T, T, built into the corners as shown.

In this spire the braces were run diagonally across the tower from hip to hip, only one pair of hips with its braces being shown.

The best method of bracing such a spire would be by means of rods placed in the sides just under the jack rafters, as shown by the dotted lines in the side elevation. By properly tightening these rods the spire can be readily straightened and made very stiff. In country places, however, rods cost considerably more than timber, so that it is generally customary to use plank for the braces.

In framing the hip rafters it must not be forgotten that one pair will always be in tension when the wind blows hard, and the splices must be made accordingly. It is also always desirable to use a centre pole for the hips to cut against. This pole should extend some distance below the peak and be stayed at the bottom by cross pieces.

The author has found that it is generally difficult to keep the anchor bolts for the hip rafters in the desired po-

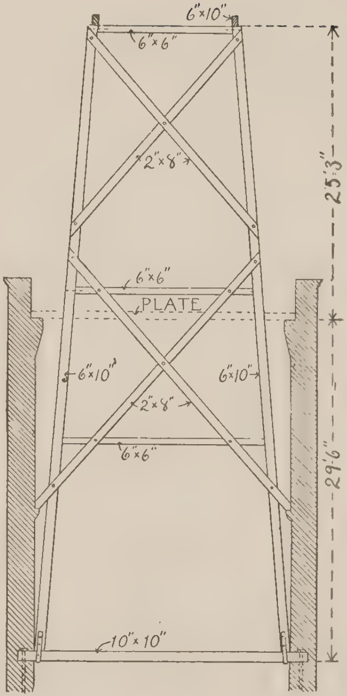


Fig. 76.

sition, and that instead of passing the bolts through the toe of the hips it is better to flatten out their upper end and bolt to the hip as shown in Fig. 78. The plate should also be bolted to the wall by shorter bolts, for the purpose of strengthening the walls of the tower and to resist the sliding tendency.

Fig. 77. shows another method of anchoring the hips. This method has the advantage that the long bolts can be put in after the hips are set in place and the nuts can be screwed up tight after the bolts are fastened to the hips. When this method of anchoring is used the plate should be secured to the wall by ¾ or ⅞ inch bolts about 3 ft. long and at least four bolts in each side of a 16 ft. square tower.

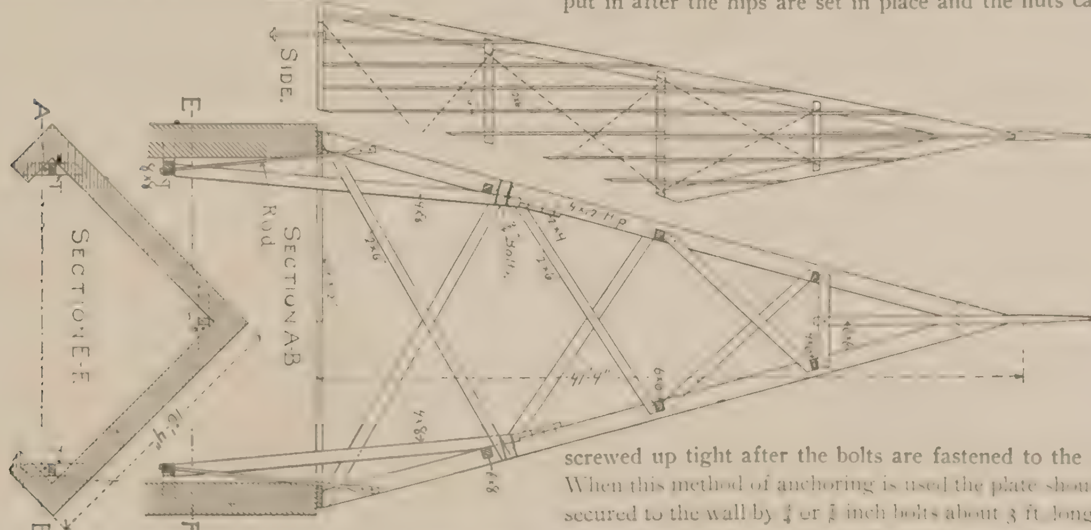


Fig. 77.

TRACERY WINDOWS

There is scarcely any feature of a church edifice

which does as much to give the building a churchly appearance as well designed tracery windows. For the more expensive buildings the tracery should be of stone, or, if a brick church, the tracery may be executed in terra cotta, especially if the tracery is repeated in several windows, so that the patterns may be duplicated.

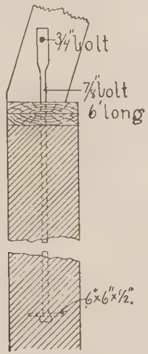


Fig. 78.

In the smaller and medium-priced churches it will be necessary, on account of the cost, to make the tracery of wood.

For this purpose only the best quality of soft white pine, cypress or redwood should be used. As a rule, the frame or tracery should be at least $5\frac{1}{4}$ ins. thick, and if the

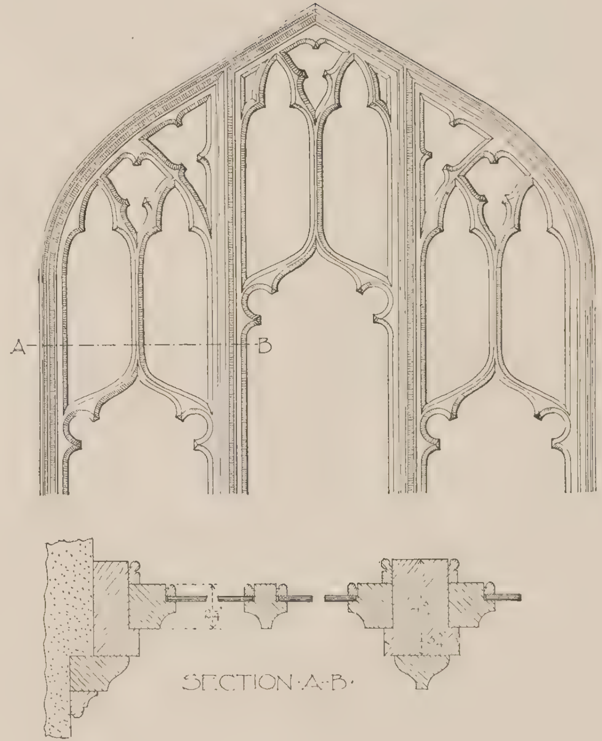


Fig. 79.


window is very large the frame should be $6\frac{3}{8}$ ins. thick. For windows up to 3 ft. wide the frame may be worked out of a single thickness of 3-inch plank, if necessary.

As a general thing, the best construction for wooden tracery is to build it up of several thicknesses of plank, cut so that the different layers will break joint well, and then put together with screws let in from the back. Just before the thicknesses are put together they should have a coat of thick white lead and linseed oil to cement them together and to prevent the rain from getting between

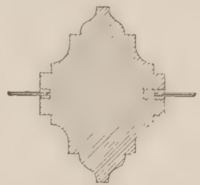


Fig. 81.

the planks. The mouldings on the edges of the planks should also be designed with a view to shedding the water. Straight mullions should be worked out of solid pieces of cypress or redwood.

Sash. Windows with stone or heavy wood tracery are not usually fitted with sashes, as the glass is set in a rebate in the wood tracery or in a groove in the stone tracery. Such portions of the windows as it is desired to open for ventilation have the glass set in an iron sash, often made of $\frac{3}{4}$-inch angle bars, and this sash is pivoted in a

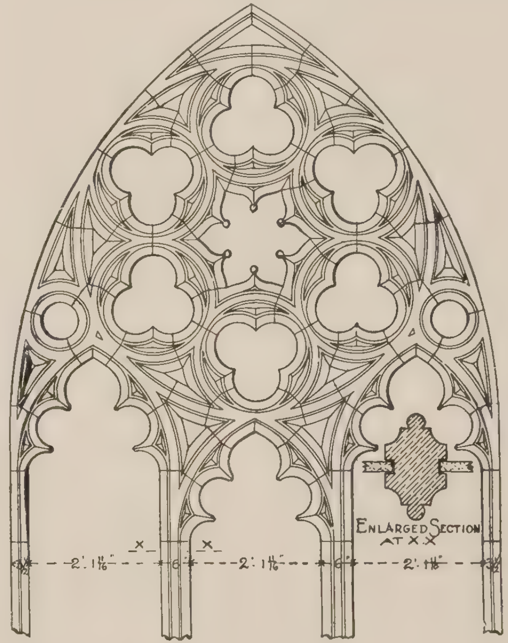
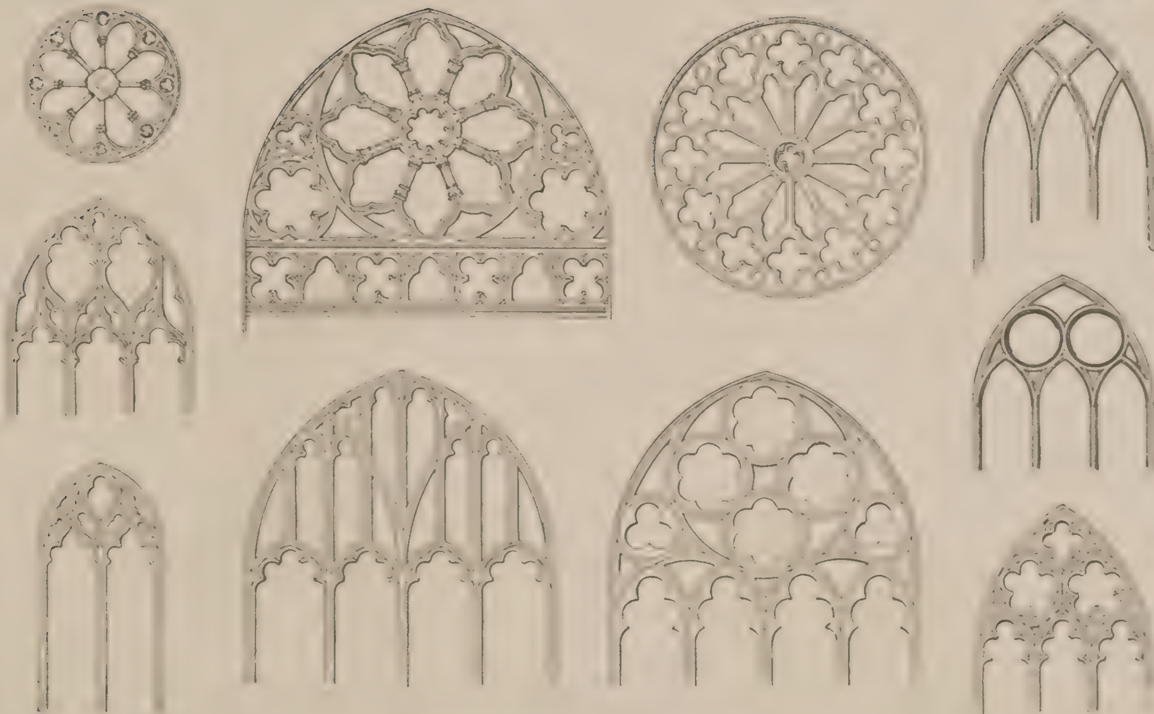
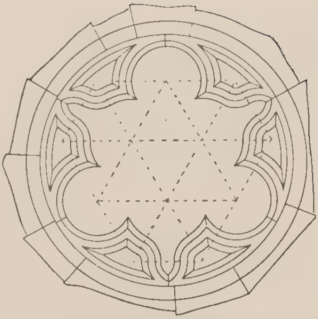


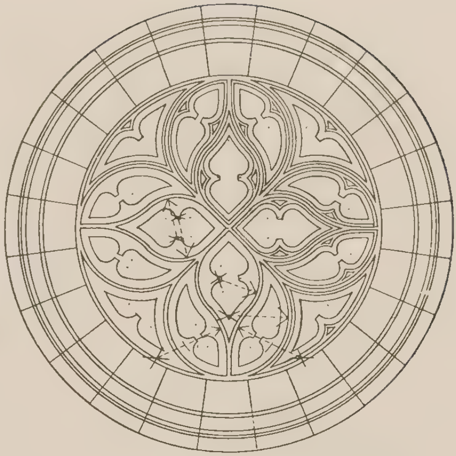
Fig. 81A.



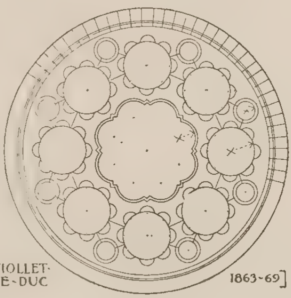
DESIGNS FOR GOTHIC WINDOWS.



ABBEY CHURCH, ESSEX,
ENGLAND.
SCALE 0 1 2 FEET

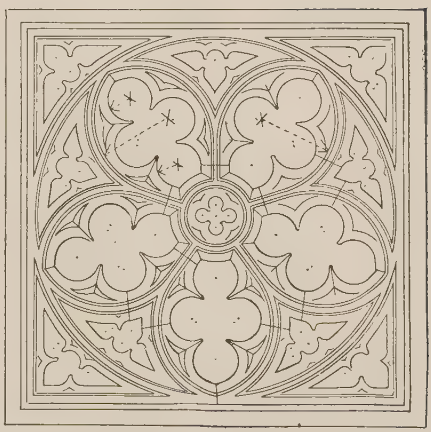


NOTRE DAME DE BROU.
[EURE-ET-LOIR]
FRANCE
SCALE 0 1 2 3 4 FEET

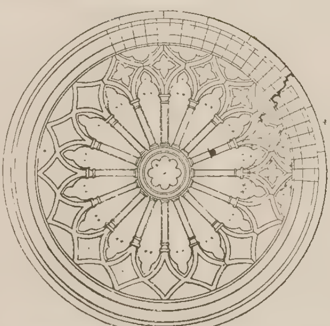


[VIOLLET-LE-DUC 1863-69]

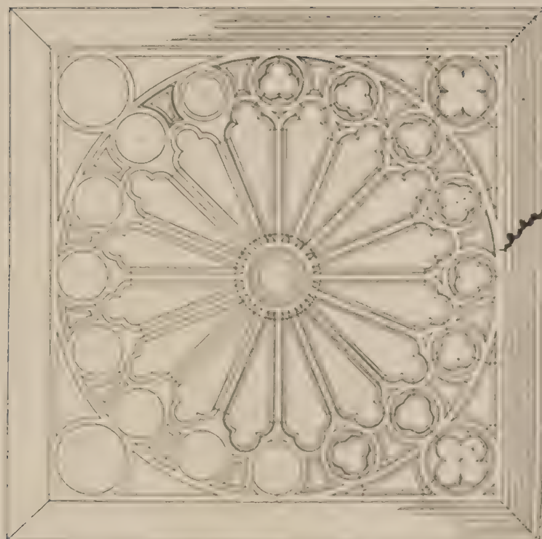
· D'AILLANT · SUR · THOLON ·
· FRANCE ·
SCALE 0 5 10 FEET.



WORSTEAD CHURCH, NORFOLK.
ENGLAND.
SCALE 0 1 2 FEET

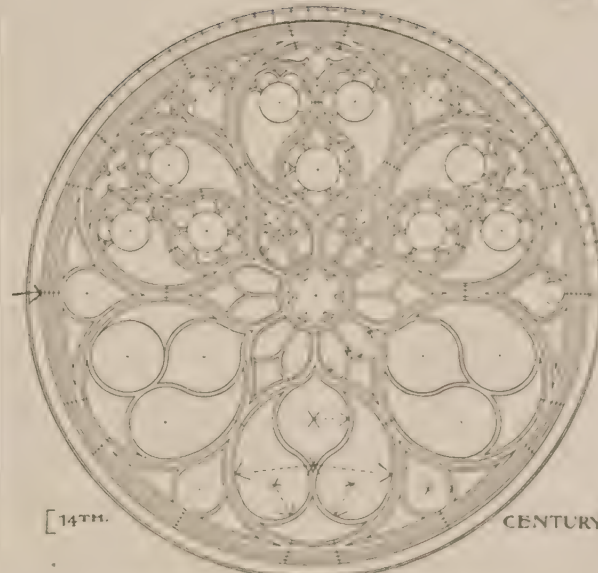


· CATHEDRAL · CREMONA · ITALY ·
SCALE 0 1 2 FEET



· MINSTER · FREIBURG ·

SCALE 0 1 2 3 4 FEET



· LYONS · CATHEDRAL · FRANCE ·
DIAMETER 15'6"

ROSE WINDOWS.

From American Architect and Building News.

slight iron frame set in the rebate of the tracery. This is the best arrangement for securing ventilation from tracery or large leaded glass windows.

For country churches, however, it is generally better from a practical standpoint to fit sash into the frames, as then the sash can be sent away to receive the glass, and there will be no chance of a misfit nor any trouble in setting. Moreover, having removable sash saves much labor in making patterns for the glass. When sash are used, part of them may be pivoted or hinged at the bottom for ventilation, or a small metal frame may be inserted in the sash, as described above. The rebate for the glass should be on the outside of the sash, and if set directly in the tracery, then the rebate should be on the inside. The cheapest tracery window that can be designed is one like that shown by Fig. 79, the construction of which is indicated by the different sections.

The window shown in Fig. 80 has a good appearance in a Gothic church, and is easy to construct. Fig. 81 shows a section of stone tracery, the groove on one side of the opening being twice as deep as on the other, so that the glass may be slipped in and slid sideways.

Fig. 81A shows a tracery window in terra-cotta designed by Mr. Thomas Cusack, and first published in The Brickbuilder. This illustration is given for the purpose of showing the correct method of making the joints in such windows. For terra-cotta tracery, it will be much cheaper to use the same profile on both sides of the window (inside and out), as this will admit of the same mold being used for double the number of pieces.

Various forms of tracery windows are shown on Plates G, H and I.

When the window is very wide, it may be necessary

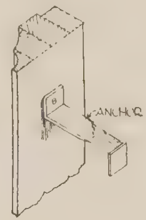


Fig. 82.

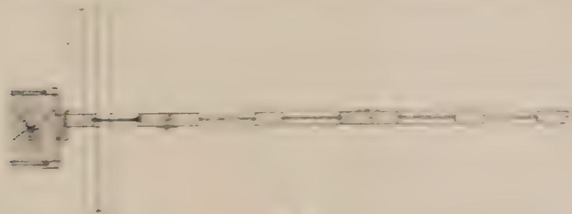
to stiffen it by an iron bar placed across the window on the inside with the ends imbedded in the masonry or fastened to the outer frame.

Window frames in a masonry wall should be secured to the wall by iron anchors, screwed to the back of the frame and built into the masonry. Fig. 82 shows a form

of anchor generally used by the author. These should be placed about every four feet in the height of the frame, and at least one on each side of the arch.

DOORS FOR LARGE OPENINGS.

The manner in which the large openings between the audience room and lecture room or between class or



Sunday School rooms shall be closed is a matter of much importance, both to the Architect and to the society, and requires a practical knowledge of the advantages and disadvantages of different devices to determine which to adopt. Openings 10 to 12 ft. square or under may be closed either by folding doors, by flexible doors coiling about either a vertical or horizontal shaft, by doors sliding into a pocket or by doors hung with weights and pulleys to slide into a pocket above.

Openings having a greater width than 12 ft., but not more than 15 ft. high, should be closed by flexible partitions or sliding doors, and when the opening is more than 15 ft. high, large doors sliding into a pocket are probably the most satisfactory device.

Folding Doors. When the opening is not more than 13 ft. wide and 10 ft. high, folding doors are the cheapest device for satisfactorily closing the opening. The doors should be divided and hung as shown by Figs. 83 and 84, the leaf next the jamb being one-half the width of the other leaves and the full leaves being not more than 2 ft. 8 ins. wide. By putting a heavy castor, made for the purpose, on the bottom of the inner leaves, doors hung in this way will be found to work very satisfactorily.

When there is room for a track above the doors, they may be suspended at their centers by swivel carriers rolling on an overhead track the same as used for parlor doors, the doors turning on the swivel as they are folded, as indicated by Fig. 84. In this way openings 25 ft. wide

can be easily closed. When doors are hung in this way, however, the track on which the carrier runs should be adjustable, so that in case of settlement in the building it may be adjusted to keep the doors clear from the floor.

Special hangers and hinges are made for hanging doors in this way, and they have been quite extensively used. One advantage of solid doors over rolling partitions is that the solid doors can be made with glass panels.

For basement openings, where there is room for a pocket, the author has used single doors 8½ ft. high and 12 ft. wide, hung with the Coburn trolley track and hanger, which have proved perfectly satisfactory and work with great ease. In fact, in a basement, it is not necessary to have a pocket, as the track can be fastened to the ceiling at one side of the partition, and the doors slid any distance.

Guillotine Doors. Where a pocket can be provided above the opening, doors hung like ordinary windows, to slide up and down, may be used, provided that the openings are not more than 10 feet wide. The doors should be built in sections about 3½ ft. high, and should be made as light as possible. As a rule, three sections will be required, and by making each of the lower sections 3½ ft. high, it will not be necessary to raise the upper section, except for appearance. The lower section should have thin, wooden panels. The upper sections may be divided by wooden muntins and glazed with double strength chipped glass. The doors should be hung with Giant metal sash chain, or one equally as strong, running over 2½-inch ball-bearing pulleys, and must, of course, be counter-balanced by iron or lead weights. The boxes in which the weights run should be divided by partitions, so that the weights will not interfere with each other. For the doors to slide up out of sight, the pulleys must be placed at least a foot above the top of the opening, and a movable panel should be provided in one side of the partition to give access to the pulleys.

When the doors are not more than 10 ft. wide, and are hung in the proper manner and properly counter-balanced, they will slide up and down very easily, but every precaution must be taken to secure the chain and weights so that they cannot possibly come unfastened. Nothing should be used in hanging the doors that can possibly deteriorate with time. The author cannot advise the use of guillotine doors for openings exceeding 12 ft. in width.

Coiling or Flexible Doors. As a general rule, the most convenient method of closing openings of moderate size is by means of flexible doors or partitions, although

such doors are more expensive than the folding or sliding doors.

The special advantages of the flexible doors, or rolling partitions, are that no large pockets are required, and when opened to their full extent the full size of the opening is utilized. They are neat in appearance and work satisfactorily.

Coiling partitions operate in two ways, (*a*) by coiling about a horizontal shaft placed above the opening,

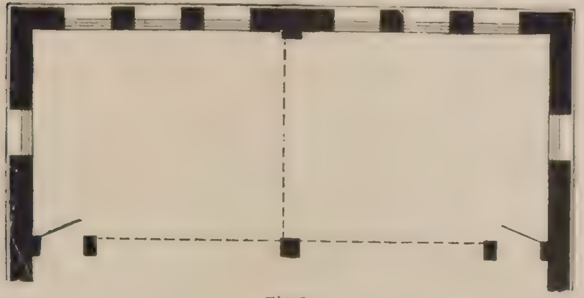


Fig. 85.

and (*b*) by coiling about a vertical shaft placed at the side of the opening; the former will be hereinafter referred to as *horizontal partitions* and the latter as *vertical partitions*.

Horizontal Coiling Partitions. The limitations of these partitions are that the opening for a single coil shall not exceed 20 ft. in height or 12 ft. in width, without division posts.

If the height is over 10 ft. it will be better to keep the width down by subdivisions to 8 or 10 ft., as the smaller the door or partition, the less will be the force required to operate it. For churches and schools a height and width of from 10 to 12 ft. will be found to give the best results, as a rule.

Where a greater width than 12 ft. is desired, the opening may be divided by permanent posts, or by guideways put up so that they can be readily removed when the partition is raised. At the sides, horizontal coiling partitions require only a grooved guideway about 3 ins. wide, but at the top a box of considerable size is required to inclose the coil.

The best method of putting up the partition will depend somewhat upon the structural conditions of the building.

The most common condition under which such partitions are used in churches is where there are several openings separated by posts which are used for the support of the floors or roof. Fig. 85, representing two class rooms separated from each other, and from the

main Sunday School room by coiling partitions, is perhaps a typical example. With such an arrangement it will be best to make the permanent posts large enough so that the box containing the coil will go between them.

A favorite method of finishing such partitions is shown by Fig. 86, which represents the elevation of a portion of the partition in a room 14 ft. high. The casing of the large post is made deep enough to receive the paneled transom inclosing the coil, an enlarged section of which is shown in Fig. 87, and transom sashes are placed above. At P is shown a removable post or guideway, which is secured at top and bottom by flush bolts so as to be quickly removed when the coiling partitions or doors are raised. Where such removable posts are used it is necessary to place a plank or an iron bracket in the coil box directly over the post to receive the end of the shafts on either side. This block or bearing may be hung from the ceiling by iron bars inclosed in the division between the transom sash, and where the transom is over 8 ft. long it should be supported in the same way. Removable posts are only required when the distance between the permanent posts exceeds 12 ft. There are two different kinds of coiling partitions made and sold by J. Godfrey Wilson Mfg. Co.

For partitions ½-inch thick, the following spaces are required inside of the coil box (*D, D,*) to permit of coiling, the actual diameter of the coil being ½-inch less:

Height of Opening	Width *D* for Partitions up to 10 feet wide.	Height of Opening.	Width *D* for Partitions up to 10 feet wide.
6 feet	10 inches.	14 feet to 15 feet	15 inches
7 feet	11 "	16 feet	16 "
8 feet to 9 feet	12 "	18 feet	18 "
10 feet to 11 feet	13 "	19 feet to 20 feet	20 "
12 feet to 13 feet	24 "		

The Wilson partitions in whitewood, ½-inch thick, varnished, are listed at 53 cents per square foot, and in

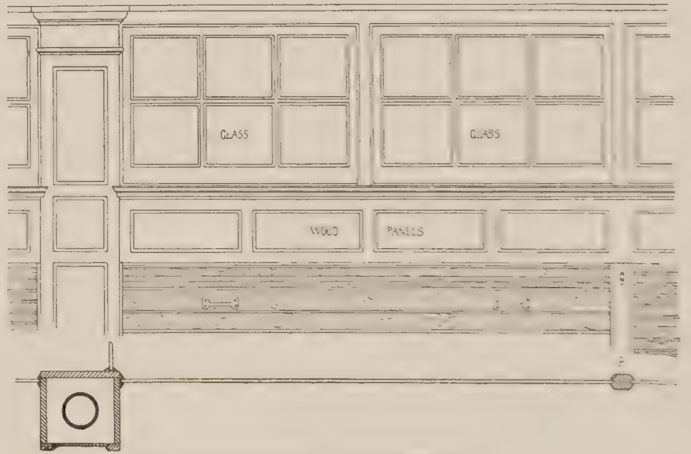


Fig 86. CASING FOR ROLLING PARTITIONS.

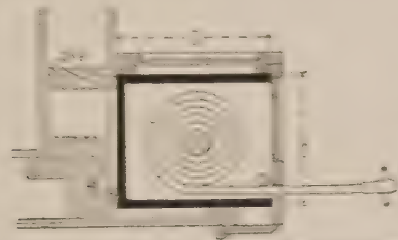
[illegible]

[illegible]

to the top of the box in which they [illegible] handles.

[illegible]

[illegible] sell for about the same price.



CASING OF COIL BOX. VERTICAL FLEXIBLE PARTITIONS.

Fig. [illegible]

Vertical Coiling Partitions. These are constructed in the same general way as the horizontal partitions, but the shaft about which the partition coils is placed vertically in a box at the side of the opening.

Vertical partitions may be used for closing much wider openings than is practicable with the horizontal [illegible] two of these doors, one at each side, without difficulty. [illegible]

the horizontal partitions, 12 ft. being the maximum height for the opening.

The vertical partitions are constructed of solid wood mouldings connected by a series of concealed interlocking steel hinges, which run through the entire width of the doors and are hung on steel rods in boxes ready for

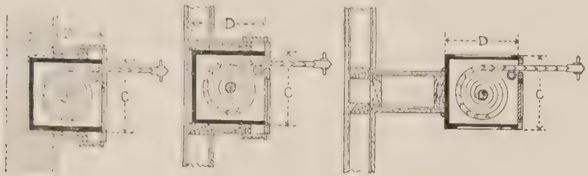


*Fig 91. Fig. 92. Fig. 93.

*Fig 90 is omitted in this edition.

shipment. The rods revolve on a ball-bearing, which reduces the friction to a minimum. The arrangement of the pocket is extremely simple, as the erection consists merely in setting the box plumb and easing it, the adjusting being done before the box is shipped.

A clearance of 3 inches over the box above the soffit of the opening is necessary for the coiling attachment. Between the coil boxes, however, the soffit may be boxed down to receive the casing.

NOTE. The James G. Wilson Mfg. Co., 3 West 29th Street, New York, will send full size detail on request, showing necessary provision for vertical or horizontal partitions.

Fig. 88 shows a typical arrangement of flexible doors dividing class rooms, and separating them from the main school room.

Fig. 89 shows the coil box for an opening 19 ft. wide, closed by a pair of doors, and one method of finishing the box, the coil box, itself being indicated by the portion in solid black.

The doors are guided by a hard-wood steel-lined track set flush with finished floor, and by a grooved guideway overhead, both of which are furnished with the doors. The coil box may be furred, lathed and plastered, and the opening finished with an ordinary casing, or the box may be cased with panel work. The soffit of the opening may be narrow, as shown in Figs. 88 and 90, or it may be furred to the full width of the jambs, as preferred. The transom shown in Fig. 88 is supported by rods from the floor beams above. To save room the coil box itself may be paneled and finished at the factory.

Figs. 91, 92 and 93 show other arrangements of the coil box, the box in Fig. 93 being paneled so as not to require casing.

Unless the opening extends to the top of the room, a post will generally be required back of the coil box to support a girder or truss placed above the opening.

Coils may be placed at one or both sides of the open-

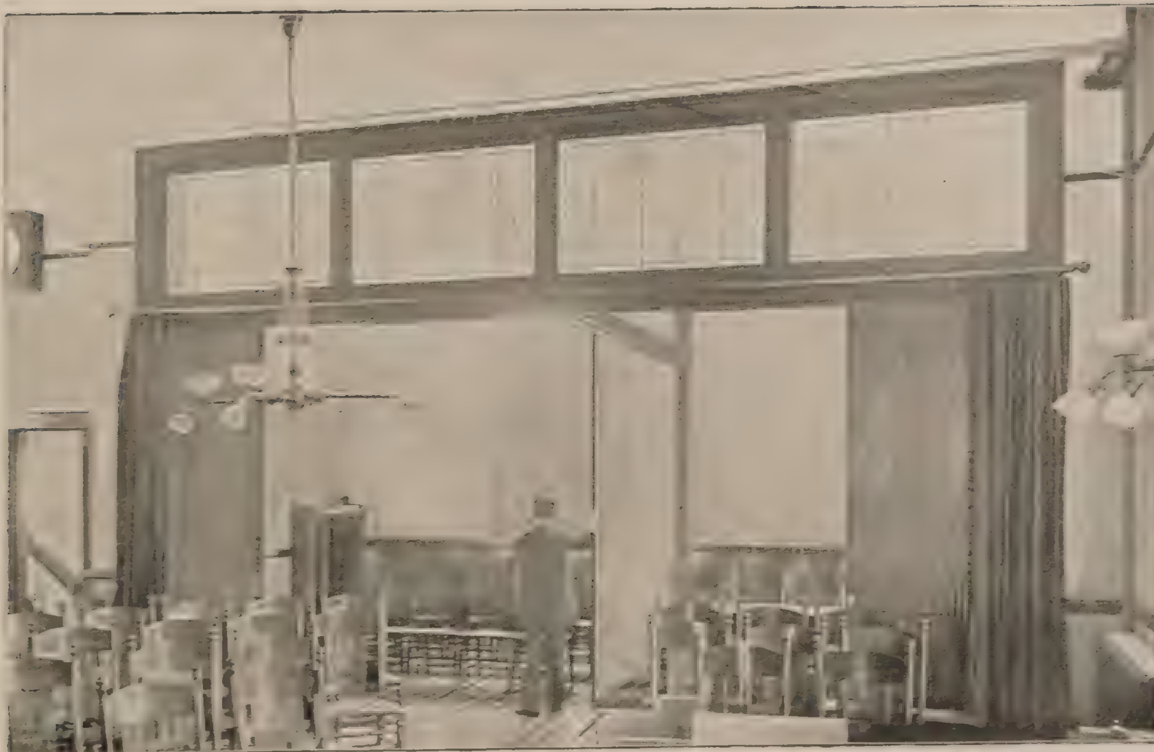


Fig. [illegible] SHOWING [illegible] PARTITIONS FORMING CLASS ROOM IN THE [illegible] PRESBYTERIAN CHURCH, NEW YORK.

HEINS & LAFARGE, ARCHITECTS, NEW YORK.

ing, as desired, unless the opening is greater than 25 ft. in width, when two coils are necessary. The dimensions of the box inclosing vertical partitions depend upon the width of the opening. Following are the dimensions for C and D, Figs. 89 and 91, for various widths of openings:

SPACES REQUIRED FOR WILSONS VERTICAL PARTITIONS.

The exact size of plates into which the partitions coil. The casings must be made large enough inside to receive them.

Width of Opening. Feet		Size of Inside Dimension of Casing. Inches
6		13½
8		14½
10	Slats ¾ inch thick	15½
12		16½
14		17½

Wherever class rooms are separated from the main school room by coiling partitions or large doors of any kind it is very desirable that an additional door of ordinary size be provided, so that the officers of the school can enter or leave the room without opening the large

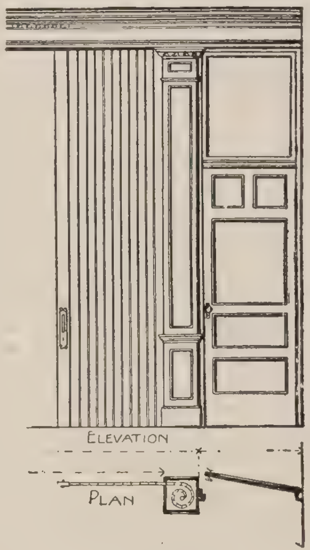


Fig. 94.

doors, such provision being especially needed when the large opening is closed by horizonal coiling partitions.

It may be noticed that in the partial plan, Fig. 85, this has been provided for. Fig. 94 shows a suggestion for a vertical partition with an ordinary door at one side, the coil box in this case being paneled.

With vertical partitions, however, a small door is not as necessary as with the horizontal partitions, as the vertical partition need only be opened about 20 inches for a person to pass through, while the horizontal partition must be raised about 5 feet.

The price of partitions depends on size of doors, kind of wood, finish, and if opening is to be closed with a single or a pair of doors.

Large Sliding Doors. For closing openings more than 15 ft. high the most satisfactory method appears to be by means of large sliding doors. The opening between the audience room proper and the lecture room of the Union M. E. Church, New York City, shown by Fig. 13, is 46 ft. wide and 30 ft. high, and is closed by six doors, each 7 ft. 8 in. wide, and 30 ft. high, three sliding to one side and three to the other. These doors are 3¼ in. thick, the rails and stiles being built up in the usual way for veneered doors. The panels are filled with very light material, and decorated to correspond with the walls of the room.

Each door has two 8-in. anti-friction sheaves fastened to its lower edge, one at each corner. These sheaves roll on a gas-pipe track, secured as shown in Fig. 95, and the operation is said to be perfect. By means of catches, the first couples with the second, and the second with the third, so that all are opened or closed at one operation. An adjustable head guide is essential on account of settlement and shrinkage, and it is very important that a firm support be provided for the track.

Mr. Geo. W. Kramer says in regard to these doors: "I have used hundreds of doors of this construction, al-

Fig. 95.

ways with success when I can get good workmanship."

Messrs. L. B. Valk & Son, who have had large experience with all kinds of doors, also favor doors sliding on sheaves at the bottom, for large openings. The section drawing shown on Plate XXX. shows doors of this character.

BAPTISTRY CONSTRUCTION.

The usual construction for a baptistry, where it is elevated above the main floor, is illustrated by Fig. 18. The bottom of the tank is supported by the main floor beams, which must of course be sufficient in number to support the weight, when the tank is full, and the sides are formed by means of 3 in. x 4 in. uprights, securely nailed to the floor beams and strongly braced. Access to the tank is obtained by means of an incline, with rubber cleats, this having been found preferable to steps. The floor and sides are then sheathed with narrow matched boards, 1⅛ in. thick, and the whole lined with tinned copper or galvanized iron. Sixteen-ounce copper, tinned, makes the handsomest and most durable lining, but is quite expensive. Galvanized iron makes a very satisfactory lining, as it is stiff, and when properly painted on the back and all seams sweated and zinced over, it stays in place well, and if kept painted on the inside will last for an indefinite time. Lead is unsuitable for a lining as it sags too much under its own weight. The tank should waste from the bottom and be provided with a pipe plug overflow not less than 1 inch in diameter. The best arrangement for warming the water is a small baptistry heater—a cast iron hot water heater with large surfaces for quick work. This may be connected directly with the tank by two 1-inch pipes, one from near the bottom of the tank and one from near the top, the water being heated after the tank is filled. Submerged heaters, using gas or oil for fuel, are sometimes used for heating the water. These are placed directly on the bottom of the tank, two pipes extending above the water for supplying fresh air and discharging the gases of combustion.

MISCELLANEOUS SUGGESTIONS.

An important point to be considered when designing a church is danger from fire. Few churches have the means to construct a fireproof building, and the few accidents that have occurred in churches from fires would not appear to warrant the expense. Much, however, can be done to prevent the rapid spread of fire, in case one should get started from the inside. All vent and hot air ducts should be made of incombustible material, and especial pains should be taken to protect the boiler room so that fire cannot originate there. The walls of the boiler room should be of brick or stone, and the door leading to it protected by tin. The ceiling should either be constructed of incombustible materials, or if the expense necessitates the use of wooden beams, they should be lathed on the bottom

with metal lath and covered with a good coat of plaster. Much may be done, in any church that has plastered walls and ceilings, to prevent the rapid spread of fire, and at a comparatively small expense, by the intelligent use of metal lathing. It is especially desirable that the under side of all stairs and all galleries be protected in this way, and the money would be wisely spent if metal lath were used throughout the building.

Another thing that is worthy of much consideration is to provide means for decorating the church at Christmas, Easter, or other festivals, without marring the walls. Just before the building is decorated the most likely schemes of decoration should be considered, and small hooks or screw eyes placed where they will be most convenient for securing the decorations. The plastering can then be patched around them if necessary, and when the walls are decorated these hooks will not be noticed, and they will greatly facilitate the putting up of the decorations and prevent breaks in the plastering that cannot well be remedied when the building is decorated.

CHAPTER VII.

ACOUSTICS.

WHILE the laws governing the propagation, reflection, dispersion and absorption of sound are well known, the application of these laws to the acoustics of building is a difficult and rather uncertain problem, and especially so when the building is designed for architectural and ecclesiological effect rather than for the simple purpose of an auditorium. Within certain limits of size and with simple arrangements, it is not difficult to insure satisfactory acoustical properties, but when the building is large and elaborate the acoustical properties are likely to be more or less uncertain.

About all that can be undertaken in this chapter is to define those principles which have a practical bearing upon the acoustics of buildings and to point out some of the conditions that are known to be favorable or unfavorable to good acoustical results. For a more scientific presentation of the subject the reader is referred to a work entitled *Architectural Acoustics*, by Eugene Henri Kelly, Ph. D., of Buffalo, N. Y., to which the author is indebted for some of the definitions herein presented.

Of the principles involved in the science of acoustics as applied to buildings, the following, perhaps, have the most direct bearing on the subject:

1st. "Sound is a graduated vibration of air waves in volume, number and composition."

2nd. "Volume is the size and density of the air vibrations: the cubical quantity of air in action or disturbance."

3d. "Sound waves travel in straight lines from point of propagation to silence by vibratory exhaustion unless deflected out of their paths by obstructions."

4th. Sound waves always rebound from hard or smooth surfaces, the reflection following the same law that applies to light, viz.—the angle of incidence is always equal to the angle of reflection.

5th. "Sound waves are absorbed, nullified or die out on dead or non-reflecting walls or soft absorbent material, such as carpets, wall draperies, plush or velvet portieres, clothing, etc., etc."

6th. "Sound waves reflected from a circular wall condense or focus at or near the generating point of the circle used."

7th. "A sound reflection is a volume of vibration

which, brought into contact with a surface, rebounds from the surface on an angle that is always equal to the angle of its contact."

Sound Disturbances. The property of sound which has most to do with the acoustics of rooms is that of reflection, as it is to this property that all sound disturbances are due.

The chief disturbances experienced in churches are resonance and reverberation.

Resonance "is the property that air possesses of continuing in vibration after propagation ceases, or the effect of a vibration of air returning from a surface or concavity and reinforcing the primary vibratory motion of the air."

A reverberation "is a sound wave forced to a point beyond vibratory cohesion, or to such an extent that the fundamental wave is separated from its upper harmonic waves."

Resonance produces an effect as though the room were filled with sound waves which seem to speak into the ears, causing a very disagreeable sensation.

The effect of reverberation is that of a separate sound or broken fragments of sound waves having the same pitch and quality as the other sound, but having a less volume.

Comparatively few churches are entirely free from resonance or reverberation, and when the disturbance is noticeable it prevents distinct hearing and speaking, and sometimes produces almost a complete failure.

With music a slight resonance is not objectionable.

According to Mr. Kelly, all reflecting surfaces (not all surfaces) that are located nearer than about 60 ft. of the point of sound propagation produce resonance; all reflectors between 60 and 110 ft. from point of sound issue produce reverberations, crashes, jars, etc., while reflecting surfaces at a greater distance than 110 ft. from point of propagation produce echoes.

An audience room may also be a failure acoustically because of the inability of the speaker to fill the space. Such failure, however, occurs only in large and lofty buildings having high open timbered roofs, domes or lanterns, or deep and narrow recesses. With such buildings it becomes necessary to introduce sound reflectors, and to reinforce the dull sound location by resonance pockets.

To design an audience room so that there will be no resonance, reverberation or echo, it will be necessary to take into account:

a. The size, shape and proportions of the room, including galleries, domes, etc.

b. The position of the origin of sound.

c. Materials and finish of walls, floor and ceiling.

d. The furniture.

e. The air currents, due to heating, ventilation or artificial lighting.

As a rule, the process of design will consist in first determining the size and shape of the room, and then adapting the other elements to favor the shape and size.

Almost any floor plan that one would be likely to adopt for a church may be made satisfactory, acoustically, if the height is properly proportioned and the walls, ceiling, fittings and furniture constructed on correct acoustical principles. Nevertheless, it is much easier to insure successful results with some plans than with others, and it is the wise course to choose as good a plan as the controlling conditions will admit.

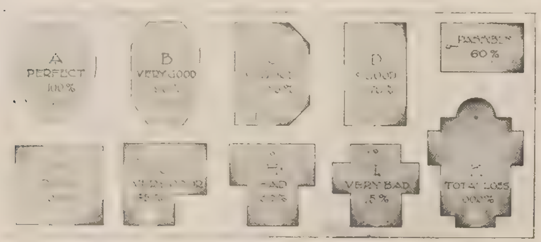


Fig. 96.

Shape of the Room. Mr. Kelly, in his work on "Architectural Acoustics," gives the relative acoustic possibilities of various shaped rooms, as shown by Fig. 96, the clouded portion indicating sound disturbances, when the speaker's desk is located at point marked O. He also gives Figs. 97 and 98 as being the ideal plan and section for a church auditorium. The outline shapes of

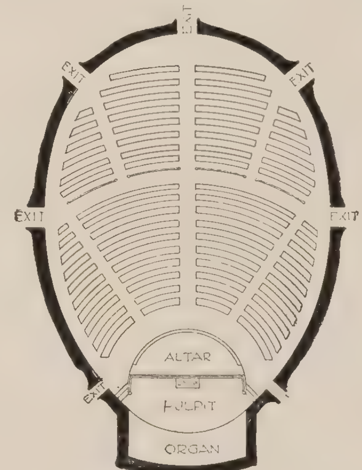


Fig. 97.

the floor plan and transverse section of the Mormon Tabernacle at Salt Lake City are shown by Figs. 99 and 100. This building is popularly considered to be the

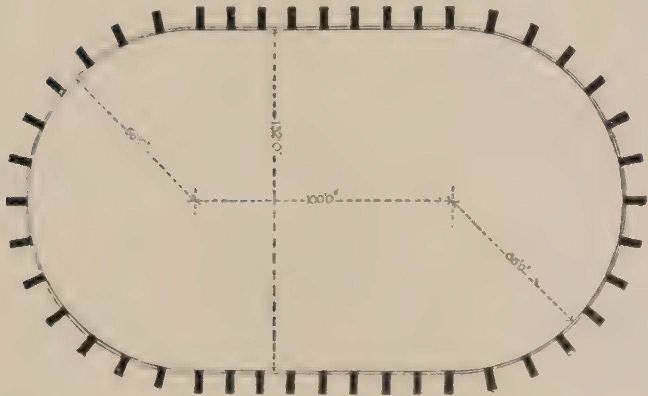


Fig. 99.

most acoustically perfect structure of any magnitude in the world.* An interior view of the tabernacle is shown by Fig. 101.

As stated in Chapter II., the oval plan cannot very well be adopted for the average church, as circular or elliptical work is very much more expensive than straight work, and the cost of roofing such a building is very great compared with other plans; it is also a very difficult mat-

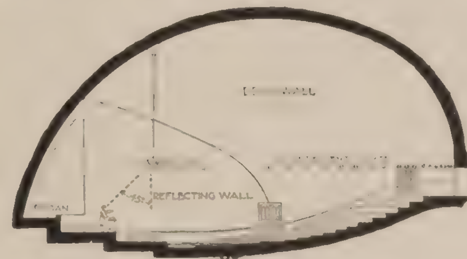


Fig. 98

Fig. 100

ter to treat a structure such as is shown by Figs. 97 and 98 in an ecclesiological manner.

*A very interesting description of this building was published in *The Engineering Record* of Jan. 27, 1900.

To obtain the benefits of the oval plan it is necessary that the ceiling be elliptical also. The present pastor of the First M. E. Church, Baltimore (see Plate XXXII.), says of the acoustics of that church: "I would not call the acoustics first-class. There is no difficulty in speaking—a whisper can be heard, but there are unpleasant echoes in various parts of the auditorium, and they tell me that in certain places in the gallery one hears an echo of an echo."

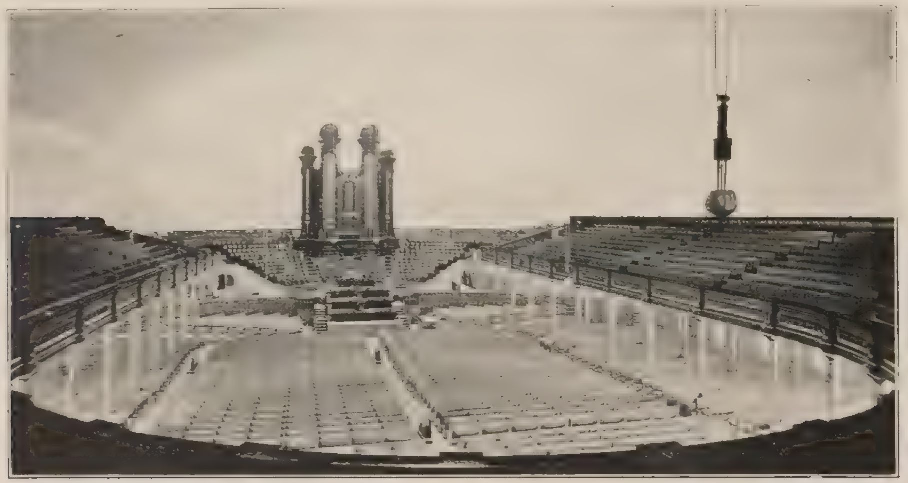


Fig. 101. THE INTERIOR, LOOKING TOWARD THE CHOIR AND ORGAN.

For churches of moderate size, there is no difficulty in making a square, rectangular or octagonal church practically acoustically perfect if the speaker's desk is prop-

erly located and proper attention paid to the construction of the walls and ceilings, and perhaps a gallery introduced. The experience of the author has been that the plan D, Fig. 96, gives more nearly perfect results than Mr. Kelly indicates. As a matter of fact, the audience room in the church shown on Plate XXIII., which is very nearly these proportions, appears to be acoustically perfect. It has a gallery, however, on three sides, a flat ceiling and a 3-ft. cove all around the ceiling.

The square plan, with the pulpit in the corner, is also generally very satisfactory, although the corner opposite the pulpit should be cut off.

In regard to the cruciform plan, the author is of the opinion that it is difficult to construct a room on this plan without having some resonance, and there are many churches built on this plan in which the acoustics are very bad, but by properly locating the pulpit, and perhaps placing a sounding board over it, the author believes that the acoustics may be made fairly satisfactory, although it is not a plan one would recommend for a lecture room or concert hall.

Proportions of Rectangular Rooms. Although no rule for the proportions of an audience room appears to be generally recognized, the following rule has been recommended by several writers on the subject, and is said to have proved perfectly successful in a number of instances where it has been adopted:

Rule. Make the height of the room equal to one-half the width, plus the distance from the speaker's mouth to the floor, and the depth (measured from the speaker) from one and one-half to twice the width, but not greater than 90 ft. The relation of height to width appears to be more important than that of width to length.

The audience room of the church shown on Plate XXIII. is 85 ft. wide above the galleries, 41 ft. deep, measured from the speaker, and 27 ft. 6 ins. high. The acoustics are practically perfect.

Mr. Kelly recommends that the depth of the room, measured from the speaker, be one-half the width, and the height equal to the depth.

It also appears to be an accepted fact that rooms intended for musical performances should have a higher ceiling than those intended principally for speaking. One writer claims that the proportion of height, width and length, as 2, 3 and 5, has proven eminently successful in several music halls.

Space Back of Speaker. Mr. Kelly says: "Do not, if it can possibly be avoided, station a singer or orator in front of or near any circular cavity. The corner of a

room is a much better location, but against a flat wall is the best."

The author has observed that where there is any recess back of the speaker there is pretty sure to be resonance, unless the recess is filled by an organ.

In large Episcopal and Catholic churches the pulpit is almost always placed against the pier at one side of the chancel, as in Figs. 1 and 102, and even then it is often necessary to place a sounding board above the pulpit.

It is never well to elevate a speaker much above any part of his audience, as the voice can be thrown upward with much less effort than downward. It is therefore advantageous to slope the floor of the audience room as well for hearing as for seeing.

Galleries, Walls, Coved Angles and Domes.

Galleries are generally found to improve the acoustics of a church, as they prevent reflection from the walls back of them, and to this extent prevent resonance or echoes.

The solid portion of the gallery front should be as low as practicable, and the upper portion made open, to prevent reflection and to admit of the sound waves passing through and being absorbed by the clothes of the audience.

The solid portions should be divided into panels or ornamented so as to break up the reflection.

Fig. 102. ST. JOHN'S CHURCH, STAMFORD, CONN.

As has already been stated, the defects of resonance, reverberation, echoes, crashes, etc., are due to reflections from the walls, ceiling and all solid portions of the room,

and if there were no reflection there would be no disturbances, although there might be difficulty in hearing in distant portions of the room, either through lack of volume in the sound or through interference of the sound waves by air currents.

In a room not exceeding 60 ft. in depth the general problem will be to prevent sound reflection from any portion of the building in front of the speaker. Various surfaces reflect sound in proportion to their smoothness and the density of the material. The best sound reflector is a polished plate glass mirror, next to this perhaps is polished marble, and then smoothly troweled cement wall plaster.

In a church, therefore, the walls should be left with rough surface, except where reflection is desired, and it is safer to use ordinary lime plaster on lath than to plaster directly on the brickwork.

The shape of the wall surfaces also has much to do with the acoustics.

Prof. Roger Smith says in his work on practical acoustics: "The formation of recesses, breaking up end walls, rounding and canting off angles, bringing the ceiling on the walls with a cove or cant, and breaking it up with groining are all methods of avoiding the risk of acoustic failure."

On the other hand, Mr. Kelly says that all circular angles or corners should be strictly avoided, and endeavors to show that it is impossible to obtain perfect acoustic results with a vaulted ceiling.

The author has never observed any bad effects from coves of, say, from 3 to 4 ft. radius, where the wall joins the ceiling.

The acoustics of the room shown by Plate XLI. is not quite perfect, owing to a slight resonance, but the author believes this to be due to the recess back of the pulpit rather than to the vaulted ceiling.

It is generally admitted that domed ceilings, or a lantern over the crossing, are quite sure to injure the acoustics of the room, although there are instances of churches with low domes where the acoustics are perfect.

Elaborate open timbered roofs are all generally considered to have an unfavorable effect upon the acoustics, but not to such a degree as domes or vaulted ceilings.

When a room of moderate size is subject to resonance or reverberation, a thick carpet or rug on the floor beneath an orator, singer or piano will subdue it, and, on the other hand, when the room is large and hard to fill, the speaker and singers should stand on a single board floor, with but a thin carpet without lining, or no carpet at all.

Carpets on the floors, cushioned seats, draperies at the windows or at openings all absorb the sound and reduce resonance.

Effect of Air Currents. When a sound wave comes in contact with a moving current of air it is deflected from its path in proportion to the density and velocity of the air wave. Therefore, for perfect sound propagation the air must be in repose, and should, moreover, be homogeneous throughout the room.

It is practically impossible to secure these conditions in a large audience room for any length of time, as in cold weather air currents must inevitably be produced by the artificial heating, and in warm weather currents will be produced from opening the doors or windows, or if the room is ventilated by means of a fan, then there will be currents produced by that. Since, then, there must be some movement of the air in the room, the supply and ventilating openings should be located so as to assist in conveying the sound waves rather than to deflect them, and, in fact, the whole system of heating and ventilating should be carefully considered in connection with the acoustics.

If a very high ceiling, dome or lantern is desired for architectural effect, the ventilation should be so arranged that the currents of air will be admitted near the pulpit, and spread out toward the walls, the exhaust being sufficient to prevent the incoming air from ascending to the dome. If the air is kept moist, it will also aid in overcoming the defect.

The effect of air currents on acoustics will be further considered in Chapter VII.

Sounding Boards. Large Gothic churches, with deep chancels and vaulted or open timbered roof are notoriously bad for speaking, and in such churches it is generally necessary to place a sounding board over the pulpit, to reflect the sound of the voice toward the audience. Fig. 102 shows the latest improvement in this line. This sounding board has been used in a large number of Episcopal and Roman Catholic churches, and appears in every instance to have greatly improved the distinctness with which the preaching services can be heard, in some cases making it practically perfect.

CHAPTER VIII.

HEATING AND VENTILATION.

THE heating and ventilating of a church building, and particularly of the audience room, is a matter of much importance, as few people are now willing to sit in a cold room or to expose themselves to draughts.

As a rule, the audience room must be warmed to secure any attendance at all on the services, and if the ventilation is good the attendance is likely to be still greater, and the congregation will be in better condition to follow the sermon.

Merely to warm the building is not a difficult undertaking, but to maintain a comfortable temperature at all times, and a constant and thorough change of air without draught requires a scientific arrangement of flues and involves considerable expense.

To be able to judge intelligently of the comparative merits of different systems of heating and ventilating, and to what expense it is necessary to go to obtain the degree of comfort and healthfulness that may be deemed necessary, one must have some knowledge of the fundamental principles of heating and ventilation, and of the various methods by which these principles are applied. To lay out a system or plant for any given building which shall best meet all of the various conditions imposed by the plan, the character of the service, successful acoustics and the financial ability of the congregation, requires also familiarity with the methods of determining the heating surface, boiler capacity, locating flues and registers, and determining their size, velocities of air currents, devices for regulating temperature, the working of fans and blowers, and many other points which can only be briefly mentioned in this chapter, our principal aim being to describe in a general way the various methods of warming and ventilation, with their advantages and disadvantages, without going into the details of size, capacity, etc.

HEAT—*Its Nature and Conveyance.*

Heat is recognized by the sensation of feeling, by means of which we are able to determine roughly by comparison that one body is warmer or colder than another. From a scientific standpoint, heat is a peculiar form of energy which is capable of being transformed into work or electricity. The intensity of heat is called temperature, and this can be measured by the thermometer.

Heat itself, however, cannot be measured by the thermometer, but is measured by its power to raise the temperature of a given weight of water. In English speaking countries the heat unit is that required to raise one pound of water from a temperature of 62 to 63 degrees, or, roughly speaking, one degree, and this quantity is termed a British Thermal Unit.

The difference between temperature and quantity of heat may be understood by the following illustration: A pound of water requires about eight times as much heat to raise it one degree in temperature as a pound of iron, and hence when equal weights of both these materials are at the same temperature the water contains eight times as much heat as the iron, although in common parlance the two bodies would be equally hot.*

There is always a tendency for heat to flow through intervening mediums, from a hotter to a colder body—*i.e.*, for the hotter body to cool off and give up its heat to surrounding objects—and if no other heat were supplied, all bodies would come sooner or later to one common temperature.

Transmission of Heat. Heat passes from a warmer body to a colder by three general methods, each of which is of considerable importance in connection with the system of heating.

These methods are, radiation, conduction and convection.

The heat which leaves the body by *radiation* travels directly and in a straight line, until it is intercepted or absorbed by some other body. Radiant heat passes through air without affecting its temperature to any appreciable extent, thus the radiant heat from an open fire or hot stove does not warm the air through which it passes, as is shown by the fact that when we stand before the fireplace the side of the body toward the fire will become very hot, while the air all around us may be cold.

Conduction of Heat. When heat is applied to one end of a bar of metal it is propagated through the substance of the bar, producing a rise of temperature, which gradually travels to the remote portions. This transmission of heat from one part of a body to another is called conduction.

The conducting power of materials varies greatly, the metals being in general good conductors; rocks and earthy materials much less, wood and water very slight, while the conducting power of air is practically zero.

The conducting power of the materials in the walls of a building has much to do with the escape of heat from the interior.

*Prof. Carpenter in "*Heating and Ventilation*"

Heating by Convection or Contact. When gases or liquids are in motion there is more or less rubbing contact of their particles with each other and against stationary objects. When the particles rub against hot bodies they will themselves become warm, and when they come in contact with colder articles they give up their heat, and their temperature will be thus lowered.

The heating of the air of a room is practically all accomplished by convection, the particles of air coming in contact with the heater and becoming warm as they rub against it. When air already heated is introduced it comes in contact with the walls, windows and objects in the room, and gives up its heat to these objects. For this reason a room cannot be kept warm until the walls have been warmed. If the walls are warm the air will take heat from them, and this is what actually happens in hot weather.

The water in a steam boiler is also heated principally by convection.

Systems of Warming. There are two general methods of warming rooms, under which all systems may be classed. One is by warming the air already in the room by a heater *in the room*, and the other is by introducing air warmed by a heater placed outside of the room.

For the first method, open fires, stoves or radiators may be used for warming, and for the second method either a hot air furnace, indirect radiators or steam coils in connection with a fan, are generally used.

An *open fire* warms the air in a room only by first heating objects in the room by direct radiation, and these objects warm the air by convection. To warm air in this way requires a great consumption of fuel, and even then it can be only partially accomplished. A *hot stove* will warm the air both by radiation and by convection. The heated surfaces of the stove radiate heat to the walls and objects in the room, which give up part of it to the air, and a current of air is constantly passing upward around the stove, thereby warming those particles which rub against the heated surface.

A radiator filled with hot water or steam takes heat from the steam or water, which is transmitted to the outside by conduction, and there gives it off to the particles of air which rub against it. A radiator also radiates more or less heat, but the radiation is much less than in the case of a stove, as a stove is usually kept much hotter.

As far as warming the air is concerned, it makes no difference whether a radiator is filled with steam or hot water, provided both are maintained at the same temperature, but as a steam radiator is usually considerably hotter than one filled with water, the former raises the

air rubbing against it to a higher temperature so as often to scorch the air, as it were, and for this reason hot water radiation is often spoken of as healthier than steam radiation. When the steam pressure does not exceed 4 or 5 pounds, however, one system is probably as healthful as the other.

Air is heated in a *furnace,* principally by convection, the cold air being taken in at the bottom of the furnace, and passing around and rubbing against the heated surfaces takes up the heat and passes on to the room which it is intended to warm. A hot air furnace is really nothing but a big stove encased in a chamber, only the stove or heater part of a furnace is constructed so as to have a greater exterior or heating surface than ordinary stoves. It is evident that the greater the surface of a heater, the more particles of air can rub against it, and hence all kinds of heaters for warming air are measured by the extent of their external surfaces. As soon as the air passes out of the furnace it commences to give off its heat to the objects with which it comes in contact, and after it has been in the room for a short time (if the weather is very cold) its temperature is reduced to that of the walls. The air in a room cannot be directly warmed by admitting hot air, as air does not appreciably heat by conduction, but the hot air forces out enough of the air that was in the room to make room for itself.

VENTILATION.

Ventilation, as applied to a room or building, consists in supplying pure air to dilute and drive out that which has become vitiated.

Perfect ventilation consists in supplying fresh air, warmed or cooled to a comfortable temperature, in such a manner that the circulation shall be constant and thorough in all parts of the room or building, and at the same time without the creation of draughts.

The evil effects of a vitiated atmosphere are due to certain poisonous gases, floating organic and inorganic matter and local impurities. In a church or audience room these impurities are given off by the occupants, and if gas is used for lighting by the combustion of the latter. The principal impurity produced by respiration is carbonic acid gas, which of itself is not particularly harmful, but as it is known that the other and more fatal impurities exist in fixed proportion to the presence of this gas, and as the relative proportion of carbonic acid can be easily determined, it has come to be the measure of vitiation of the atmosphere. "When carbonic acid is present in a room in excess of 10 parts to 10,000 parts of air, a feeling of weariness and stuffiness, generally accompanied by a headache, will be experienced, while even with 8 parts in 10,000 parts a room would be con-

sidered close. For general considerations of ventilation the limit should be placed at from 6 to 7 parts in 10,000."

In most audience rooms, when all seats have been occupied for some time, and no system of mechanical ventilation is provided, the proportion of carbonic acid will run as high as 20 parts in 10,000 parts of air.

Air Supply Required for Efficient Ventilation. To dilute the air so that the products of respiration and absorption from the skin of an average adult will not increase the proportion of carbonic acid beyond 7 1-3 parts to 10,000 parts of air requires the introduction of 30 cu. ft. of fresh air per minute per person, and in Massachusetts a law has been passed making this the minimum volume to be provided in schoolrooms. Whenever fan ventilation is attempted this basis of 30 cu. ft. per minute should be considered as the minimum supply.

Methods of Ventilation. For the purpose of explanation there may be said to be three methods of ventilation; a, natural ventilation; b, ventilation by aspiration, and, c, fan or power ventilation.

Natural Ventilation includes such as may be produced by fire places, doors and windows, furnace heating, and vent shafts and cowls not provided with artificial means of producing a draught.

A fire place will exhaust air from a room when a fire is burning in the grate, but is almost sure to produce unpleasant draughts. Heating by hot air from a furnace, or indirect steam or hot water radiation, will also insure a certain degree of ventilation, for it is certain that if air is entering a room an equal quantity of air must be passing out.

Flues built in the wall to carry off the impure air, or to produce ventilation, are almost entirely useless unless a considerable difference in temperature between the flue or shaft and the external air is maintained. Many persons appear to think that there is always a draught in flues or high stacks. This is not the case—there can only be an upward current when the air in the flue is of a higher temperature than the external air, and even then the effect of friction may be sufficient to prevent any appreciable draught. Occasionally a slight draught may be produced by winds blowing across the top of a vent flue, or the heat of the sun on the exposed portion of the chimney may produce a slight draught, but such occurrences are too unreliable to be depended upon.

Very often, when a room is warmed by hot air, and flues are provided in the walls for the air to pass out of, the air will pass out around the windows and doors, and even through the walls, while there will be no draught at all in the vent flue.

Ventilation by Aspiration includes all systems in which vent flues are provided, and also some means of heating the air in the flue to produce an upward draft. One of the most successful applications of this method is

A draught may also be produced in to use a heavy galvanized iron smoke-stack, located in the center of a large brick chimney, for carrying off the smoke from the furnace or heater, and utilizing the space around the smoke-stack for ventilation. This will insure a positive draught when the furnace is in operation, but when there is no fire in the furnace there will be no ventilation. Building a vent flue, in the same chimney with the smoke flue, but with a 4-in. brick partition between, will work in the same way, but not with so much effect. The brick flue is much more durable, however, than a galvanized iron flue, as the latter is liable to rust out in the course of 10 or 12 years.

Fig. 103.

A draught may also be produced in a vent flue by means of coils of steam pipes placed in the flue just *above* the register or air inlet, or a gas heater may be employed for heating the flue. The author has used steam radiators in vent flues, but without much success.

Fig.103 shows a device used in a church in Chicago for producing a draught in the flue, by means of a gas jet, which, it is claimed, has worked successfully.

In general, however, ventilation by aspiration is only partially successful, and to ventilate a large room in this way with any marked degree of success will usually cost more than to do the same work with a fan or blower.

When the smokestack is used for producing aspiration it is, of course, without expense, and for small churches this is a most excellent way of exhausting a certain amount of the air.

Fan or power ventilation consists of either forcing air into a room, or exhausting it from the room by means of a fan or blower.

By means of a properly designed fan system air can be moved with certainty and with a constant volume, and it is the opinion of the author that only in this way can thorough and positive ventilation of a large audience room be attained. Ventilation obtained by forcing air into the room is known as the *Plenum* or Hot Blast method; when the fan is arranged to withdraw the air from the room the term vacuum, or exhaust method, is almost universally applied.

The Exhaust Method. There are many objections to the adoption of this method in this country, and as a rule it should be avoided when the Plenum method can possibly be used. When exhausting, a partial vacuum is created within the room and all currents and leaks are inward so that air rushes in through every crevice around doors and windows, thus forming unpleasant and sometimes dangerous currents of cold air. The circulation of the air in the room is also, as a rule, less thorough when exhausted than when forced in.

The Plenum Method. On the other hand, when the air is forced in, temperature and point of admission are completely under control; all spaces are filled with air under a slight pressure, and the leakage is outward instead of inward. The denser the air, also, up to a certain limit the better it is for comfort and good acoustics, as the denser the atmosphere when dry, the easier sound waves are propagated by a speaker, singer or an instrument, and the fuller the sound will be when received by a listener.

The application of the fan to heating and ventilating will be considered further on.

Systems of Heating and Ventilation.

The various ways in which a church may be heated may be divided as follows:

Heating Without Ventilation.

A. By stoves.

B. By steam or hot water direct radiators.

Heating and Ventilation.

C. By hot air furnace and natural ventilation or aspirating flues.

D. By a combination of direct and indirect steam radiation.

E. By indirect steam radiation, and exhaust fans.

F. By the Hot Blast System.

Stoves. Very small churches, especially in the country, are often obliged to depend upon stoves for heating the building.

When such is the case some kind of ventilating stove should be used; that is, a stove encased with an iron jacket, so that the air will ascend between the stove and the jacket and come out at the top, heated. A stove encased in this way will give out much more heat, for the fuel consumed, than one not encased, and if a cold air duct is provided, so that fresh air may be admitted under the stove, some amount of ventilation will be secured. Stoves as ordinarily used offer a very unhealthy method of heating.

Heating by Direct Radiation.

The method of warming a room by means of hot water or steam radiators or coils of pipe located in the room is commonly spoken of as "direct radiation," although the room is really heated almost entirely by convection. The air of the room rubs against the radiator, becomes heated, and by the law of gravity rises toward the ceiling, allowing other particles of air to rub against the radiator and follow the same course. In this way there is a constant current of air ascending around the radiator, and if the doors and windows are closed much of the air will come back to the radiator and be warmed several times in the course of an hour.

With this sytem, no provision is made for supplying fresh air to the room, except through doors and windows, and if vent flues are provided they seldom have any effect on the atmosphere of the room. A large room or building can be thoroughly warmed with a less consumption of coal by direct radiation than by any other system of heating, and if it were not for the lack of ventilation it would be an almost ideal system of heating.

The great advantage of steam or hot water heat is that the radiators can be located just where the heat is wanted, and the steam or water carries it there without regard to wind or exposure, or to how many rooms there are to heat. The principal difference between hot water heat and steam heat is that with hot water the radiators must be larger than for steam, and the radiators and piping are always filled with water, which, if warmed to even 100 degrees, will give off some heat. With steam radiators there can be no heat in the pipes and radiators until the water in the boiler is brought to the boiling point; and when there is no fire under the boiler the radiators will be empty, and hence cannot freeze. With hot water radiation, a fire must be constantly maintained throughout the winter months, or else the water drawn off every time the fire goes out to prevent freezing of the pipes and radiators, and there is always danger that in the spring or fall a sudden cold snap may find the radiators filled with water and the fire out, and almost ruin the piping and radiators by freezing and bursting. For this reason the author cannot recommend the use of hot water for warming churches, except where the building is kept warm all the week and a competent fireman or janitor employed. A hot water plant costs more to install than a steam plant, and will not warm a building as quickly.

A certain amount of direct radiation is generally used, even with the fan systems, for warming the halls and smaller rooms, and often to assist in keeping the walls of the audience room to the desired temperature.

Wherever heating *without ventilation* is desired, di-

rect steam radiation will always be found satisfactory.

Heating by Hot Air Furnace, and Vent Flues.

Churches of moderate size can usually be comfortably warmed by one or two hot air furnaces, and where the conditions are favorable for furnace heating it offers several advantages over other systems, and especially where close economy must be practiced. In the first place, it costs much less to put in the furnace and piping than to install a steam or hot water plant, and there is no possible chance for an explosion. Any intelligent person can run a furnace, while a steam boiler requires an engineer. The repairs on a furnace will also average less than on a steam plant. When the audience room is warmed only on Sundays there will also not be much difference in the consumption of coal, as the economy of steam is only manifest when the apparatus is run continuously.

When properly installed a furnace also insures a fair supply of fresh air, and by wisely locating the registers, and providing heated flues for carrying off the vitiated air, some degree of ventilation is obtained which may be sufficient when the rooms are not crowded.

The greatest difficulty in heating by hot air from a furnace lies in conveying the heated air to the windward side of the building or room, for the reason that on a cold day, with a strong wind blowing out doors, it is practically impossible to force hot air (except by a fan) to travel in a pipe against the direction of the prevailing wind, as the air will endeavor to escape through the pipe that leads in the direction the wind travels.

For this reason, when the Sunday School room and Audience room are both on the same floor, they can be more efficiently heated by placing a furnace under each room than by attempting to do the same work by one large furnace.

It is also usually more economical of fuel to have two furnaces, for the reason that during the week the smaller one can be used in warming up for prayer-meetings, sociables, etc., and the larger furnace used only on Sunday.

The furnace should be located so that the pipes leading to the windward side of the Audience room and Sunday School room will be as short as possible.

In fact, long horizontal pipes for the main rooms should be avoided. Very often a room 50 feet square can be heated better from one larger register placed directly over the furnace and on the windward side of the building than from several openings, for if the air can be introduced on the windward side it will circulate throughout the room.

When heating by furnace, one that has large heating surface in proportion to the grate area should be selected,

as it is much healthier, and also more economical, to warm a large volume of air to about 100 degrees than to heat a small volume to two or three hundred degrees.

"Two furnaces with a low fire are very much better in all cases than one furnace with a roaring hot fire, as two furnaces with low fires will give a large supply of heated air at a healthful temperature, while a furnace with a very hot fire will supply only a small quantity of highly heated air in a very unhealthful condition, besides having a great tendency to form heat currents to the detriment of acoustics."

When the furnace is heated very hot it also radiates a great amount of heat, which is largely lost.

The general principles governing the location of registers are explained further on in this chapter.

A well arranged furnace system in connection with vent flues heated by gas jets was described in "Carpentry and Building" for October, 1898.

Heating by Direct and Indirect Steam Radiation.

The term indirect radiation is used to designate the system of heating the air supply by radiators placed in a tight box, the bottom of which is connected with a duct leading to the outer air, while from the top of the box a hot air flue leads to the room to be heated. The radiator is placed in the middle of the box, so that the air in passing through it becomes heated. The difference between indirect heating and furnace heating is that in the first method the air is heated by a radiator filled with steam or hot water, while by the second the air is heated by the furnace, and also that with indirect radiation a separate radiator is usually provided for each hot air pipe, so that the heated air must go in the desired direction. By indirect radiation, also, the air seldom becomes overheated.

When a hot blast system cannot be used on account of the expense, the author advocates heating by direct steam radiation (wherever the floor area exceeds 5,000 sq. ft.), and providing enough indirect radiation for ventilation; i. e., using enough direct radiators to keep the walls warm, and depending upon the indirect radiators for a supply of fresh air warmed to about 90 degrees.

For a church covering 5,000 square feet of ground area such a system will cost no more for maintenance than a furnace system, and the rooms can be kept much more comfortable. With such a system there should be no difficulty in warming any part of the building, and if heated flues are used for carrying off the air, a fair degree of ventilation can be secured, as much, at least, as is possible without a fan.

Fig. 104 shows a desirable arrangement for the indirect radiation. The radiator box should not be in direct communication with the outside opening, as if the radia-

tor does not drain thoroughly it will freeze and burst when there is no steam on. There should also be a sliding damper in the cold air pipe, so that connection with the radiator chamber may be entirely cut off at the close of the service.

It will also be economical to connect the bottom of the radiator chamber with a register in the floor of the audience room, or in a vent flue, so that the air can be drawn from the room before the people assemble. In Fig. 104 the vent register is utilized for taking air from the room, a pair of dampers being arranged at d and d1, so that when d is closed, d1 will be open, and vice-versa. When the steam is turned on to the radiators the damper in the cold air box should be closed, and damper d1 opened. This will permit the air in the room to circulate through the radiator, and up the hot air flue into the room again. By doing this the room can be warmed more quickly than if the air is drawn from out doors. As soon as the people begin to arrive, damper d1 should be closed and the damper in the cold air box opened.

[Note. Dampers d and d1 should be placed in the vent flue and not in the hot air flue.]

A tempering damper, E, should also be arranged in the base of the hot air flue, so that if the room becomes too warm this damper may be opened, and thus allow a portion of the cool air in the flue to mix with the warm air. This will reduce the temperature without lessening

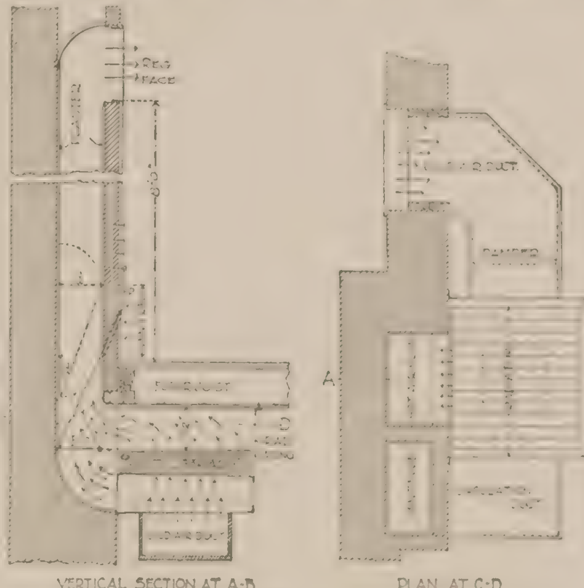


Fig. 104.

the air supply. The damper may be controlled by a chain and ring in the audience room, as indicated. By using

enough of these radiators as large a supply of fresh air as is needed can be obtained, provided there is also a good system of vent flues.

A very good application of this system of heating is described in the *Engineering Record* of Feb. 25, 1893.

In computing the *direct radiation* for an audience room, warmed in this way, add together the glass surface ¼ the exposed wall surface and 1-50 the cubic contents, and divide the sum by 4. The result will be the amount of radiating surface in square feet.

The *indirect radiating surface* may be computed by dividing the cubic contents of the room by 300, figuring that the air in the room is to be changed three times during the hour. The area of the hot air duct in sq. ft. should be 1-20 of the indirect radiating surface.

Example. What amount of indirect radiating surface should be used for ventilating a church containing 90,000 cu. ft., the walls to be heated by direct radiation?

Ans. Dividing 90,000 by 300, we have 300 sq. ft. as the total amount of indirect radiation required. Dividing this by 20 we have 15 sq. ft. as the total sectional area of flues. The radiating surface may be divided into two or more stacks, and each flue proportioned to the size of the radiator.

[Note. The above rules for radiating surface will need to be modified more or less to suit locality, exposure, character of building, etc., and should be checked by local experience.]

Exhaust Ventilation. The principal defect in warming and ventilating audience rooms, either by furnaces or indirect steam radiation, lies in the difficulty of introducing sufficient fresh air, particularly in moderately warm weather, and of securing proper circulation of the air that is admitted. Moreover, when the heat is shut off no ventilation at all is afforded. This defect can be overcome to a great extent by conducting the ventilation or exhaust flues to a chamber 6 to 8 ft. square under the roof, and placing a disc fan in it, which will exhaust the air and throw it out through an ornamental ventilator on the roof. The fan should be run by an electric motor.

Where the conditions are favorable for the adoption of this system it will afford a positive circulation of air and very fair ventilation, and also increase the efficiency of the heating apparatus. The fan can also be used to ventilate the rooms in warm weather as well as when the heating apparatus is in use. This system, however, costs as much to maintain as a hot blast system, and from the fact that it creates a partial vacuum rather than a plenum, is not as desirable a system of ventilation as the hot blast

system. The fan must also be carefully insulated to prevent the noise being heard in the audience room.

THE HOT BLAST SYSTEM. Although there are ardent advocates for the various systems of hot air heating by natural ventilation, it is now quite generally admitted, especially by those most competent to judge, that a church or any other building in which large numbers of people assemble can be more efficiently heated and ventilated by the hot blast system than by any other.

The term, "hot blast system," as commonly used, refers to those methods in which the principal rooms are warmed and ventilated by air that has been driven by a fan or blower over the heating surface, or around it, as required to produce the desired temperature, and thence through the various pipes into the room or rooms to be warmed. This term also usually implies a heater formed of coils of steam pipes, concentrated in a single "bank" adjoining the fan, although hot air furnaces may be substituted for the steam coils, as explained further on.

Unless the building is very large or complicated a single fan is used to force the air, and all of the air supply is taken into the building at one point. The fan maintains a slight pressure of air in the rooms warmed, as explained under the head of "plenum ventilation," and hence if flues of proper size, leading to the top of the building, are provided, the air will naturally seek that way of escape.

Fig. 105 shows a typical arrangement* of fan, heater and warm air chamber as usually applied to churches. The fan is located at one side of the fresh air chamber, so

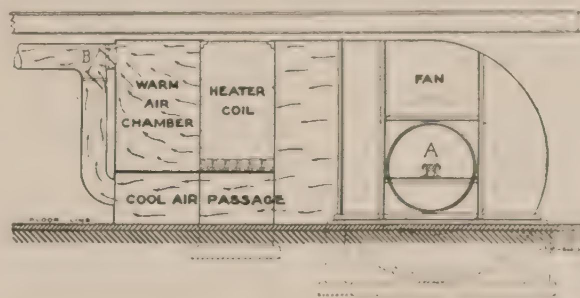


Fig. 105.

that the air is drawn into it at A, and is forced through the heater into a warm air chamber, from which ducts, properly proportioned in size, lead to the inlet registers in the rooms to be warmed.

By the arrangement illustrated in Fig. 105, the fan is placed between the heater and the cold air chamber, and *forces* the air through the heater. The fan may, however,

*From the catalogue of the American Blower Co.

be placed on the other side of the heater, so as to *pull* the air through it by exhaustion, at the same time forcing the heated air into the ducts.

Both arrangements are in common use, but for a church it is usually more convenient, on account of the simpler arrangement of the mixing dampers, to place the fan as shown in Fig. 105. This will be further considered under the head of "Mixing Damper."

The general arrangement of a hot blast system in a church is well illustrated by the floor plan of the Wesley M. E. Church, in Minneapolis, shown by Fig. 106, although the position of the fan and heater will depend in a great measure upon the plan of the building.

Other interesting examples of the application of the hot blast system to churches are described in the *Engineering Record*, for June 10, 1893, and Aug. 29, 1896.

Advantages. The special advantages of the hot blast system over the so-called natural systems of heating and ventilating are that the degree of heating and ventilating desirable can be attained with a much less consumption of fuel by the former than by the latter; the building can be warmed in a shorter time, and the system cannot be affected by the stress of weather, as the force available is always sufficient to overcome the counter effects of winds or difference of temperature. All inward draughts from around the doors and windows are also avoided.

In other words, the fan system is positive and reliable, while the natural systems are uncertain in action and likely to be unsatisfactory in character.

Design and Calculations. To properly design and lay out a system of hot blast heating and ventilation re-

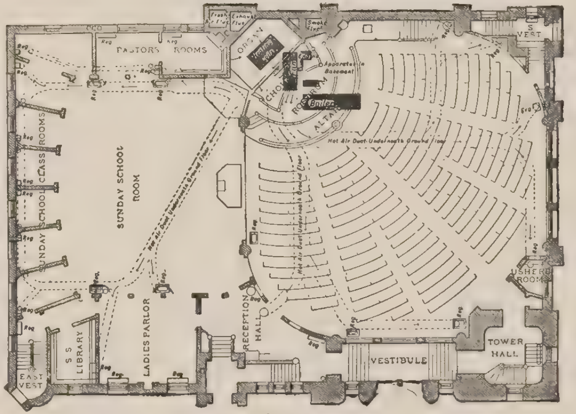


Fig. 106.

quires a comprehensive knowledge of the entire matter, both from a theoretical and practical standpoint, and more or less experience in the application of the system. Space will not permit the author to dwell upon the details of the system, except in a general way, without at-

tempting to go into the matter of calculations as to size of heater, fan, size and section of ducts, etc. Much valuable information on these points will be found in the catalogues of the Buffalo Forge Co., and of the B. F. Sturtevant Co., and also in Prof. Carpenter's work, entitled, *Heating and Ventilation of Buildings,* and published by Messrs. John Wiley & Sons.

FANS.

Three types of fans are used in connection with the heating and ventilating of buildings, viz.: the blower or paddle wheel fan, Fig. 107; the disc fan, Fig. 108, and the cone fan, Fig. 109.

The disc fan receives the air at one side and delivers it at the opposite side, the principal motion of the air being parallel with the axis.

The paddle wheel fan, and the *cone fan* receive the air at the centre of the wheel and discharge it at the circumference. The former is always used with a casing, having an outlet on its circumference which admits the air to the warm air chamber or air duct. The cone fan is generally used without a casing, the air being drawn from the outside and discharged into the same apartment in which the fan is placed.

With the pressure, or hot blast system, a fan or blower of the "paddle wheel" type is nearly always used, as such fans are best adapted to handling large volumes of air at a low pressure and with the least expenditure of power. The fan is commonly enclosed in a steel casing, as is also the heater, and the warm air chamber is usually formed of the same material, the whole apparatus being

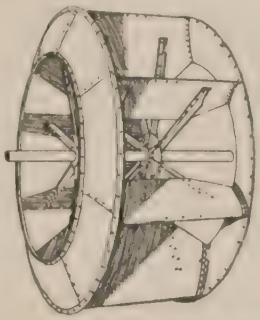


Fig. 107. PADDLE WHEEL FAN OR BLOWER.

united so as to form essentially one piece, as in Fig. 105.

When the friction and resistance of the ducts is not too great the disc fan may be used for driving the air, and some heating and ventilating companies prefer to use this fan wherever possible, as it "requires but one-half to two-thirds the power required by the paddle wheel fan to move

the same volume of air under a slight resistance." "It is probably the best form for exhaust or suction fans, and may be used in improving the draught of a ventilating flue." It lacks ability, however, to force air against a very great resistance, such as that offered by a compli-

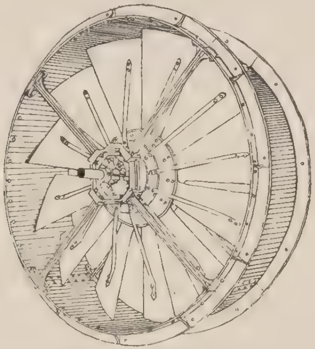


Fig. 108. DISC FAN.*

cated system of distributing pipes. Most churches that can afford a hot blast system would require a blower, or paddle wheel fan.

Use of the Cone Fan. Sometimes it is advisable to admit the heated air into an auditorium by means of a very great number of small openings, placed either in the riser of shallow steps or in the ends or back of the seats, and to do this it is necessary to have a plenum chamber

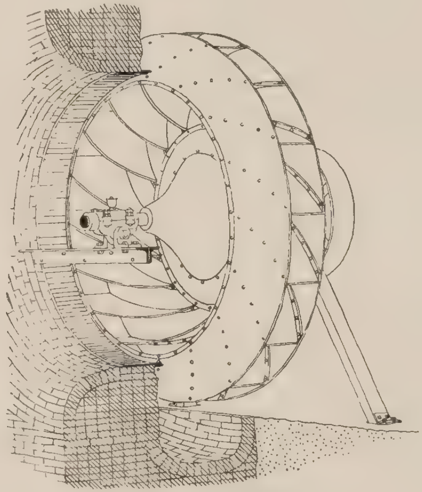


Fig. 109. CONE FAN.

under the floor. To keep this plenum chamber filled with air under a slight pressure, the cone fan is very economical, and possesses marked advantages over a disc fan, in that it will deliver air against resistance and without any

*Made by the American Blower Co

back lash. Large numbers of these fans have been designed by Prof. S. H. Woodbridge for prominent buildings throughout the country.

Power. When steam is used for heating the air, and the building is to be kept warm most of the time, steam will be the most economical power to use for driving the fan, but if the fan system is to be used only once or twice a week, an electric motor will usually be found the cheapest, provided that the electric current can be obtained from the street lines at a reasonable cost. The economy of the electric motor over a steam engine is due principally to the practicability, with this power, of using a gravity system of heating, which means less expense for attendance, as an electric fan system with gravity steam heat requires little more skill in attendance than the ordinary direct steam heating apparatus; and hence can be cared for by the janitor, provided he be possessed with a reasonable degree of intelligence. To the average church this means quite a saving in expense during the year.

Another great advantage of electric power over steam power is that with the latter the fan can be started at any time during warm weather, to furnish ventilation, and run as long or short a time as desired, and at a comparatively small expense. In fact, this is one of the great advantages of the hot blast system of heating, that it can be used as effectively in warm weather for ventilation as in cold weather for heating.

Of the numerous churches in which the hot blast system has been installed probably two-thirds of them use the electric motor for driving the fan.

Mixing Damper. In the most approved construction the fan is operated at a constant speed, so as to deliver a uniform amount of air.

To maintain the desired temperature in the room or rooms dampers are arranged at the heater so that a portion of the cool air may enter the delivery ducts without passing through the heater. Or, in other words, the air in the delivery duct is tempered by mixing with it a certain amount of cool air. This regulates the temperature without limiting the air supply. For a church, where the heated air is practically all delivered into one room at any given time, this method, known as the single pipe method, is almost invariably used. For school rooms a double pipe method, arranged so that the supply to each room or register is tempered independently of the others, is generally recommended; but for a church this involves an additional expense in installation, without corresponding advantages.

Several arrangements of mixing dampers may be de-

vised, according to the space available for the apparatus, and the position of the fan relative to the heater.

In Fig. 105, the mixing damper is at B, the cool air passing beneath the heater. In Fig. 118, which shows the fan system applied to hot air furnaces, the mixing damper is at X, and is arranged to slide vertically, so as to close the hot air inlet by the same amount that the cool air inlet is opened.

The mixing dampers may be controlled automatically by a thermostat placed in the auditorium, or by hand, by means of a chain and handle. The latter is the least expensive, and when given proper attention will be found satisfactory.

For a church, provision should be made so that the full air supply may be passed around the heater, as the body of heat from a packed audience will, after the walls are warmed, usually furnish all the heat that will be needed, and especially so in mild weather.

When steam is used for heating, tempering coils are usually placed in the cold air duct, so that all of the air is warmed to about 60 degrees before it reaches the fan or heater.

Location of Fan and Heater. "Broadly speaking, the relative position of the apparatus to the space to be heated should be as central as is practicable. Then the arrangement of the conveying hot air pipes or ducts will usually be the least complicated, and hence entail the smallest outlay. To secure a uniform distribution of air, however, this is not absolutely essential. Whenever it is not feasible to locate the apparatus centrally, the best results will generally be obtained by choosing such a position that the heated air, through the medium of well arranged distributing ducts, will constantly be forced by the fan toward the most exposed portions of the building."

Where steam heat is used, the boiler need not be near the heater, as there is no difficulty in conveying the steam to any point of the basement.

Perhaps the most common position of the fan and heater, in one-story churches, is under the choir, but they are often placed under the lecture room, and sometimes in one corner of the basement, or near an outside wall.

Location of Inlet Registers. "The best method of introducing air into rooms is not determined with any very great amount of precision by different authorities; indeed, it will be found that there is a great difference of opinion on this subject. Some eminent engineers contend that all the fresh air should be introduced at the bottom of a room and taken out at the top; others equally eminent contend that all the fresh air should be introduced at the ceiling and taken out near or at the floor. There are very strong arguments for both methods, and it is doubt-

less true that either the one or the other may be used under special conditions.

"It is a fact which is well proved by experiment that the diffusion of air will be affected greatly by the velocity of the entering air, by the position from which the air is supplied and by the form and dimensions of the room. Consequently, the method which may be successful and give good results in rooms of certain proportions would fail altogether with rooms of a different form."[*]

For a rectangular room, not exceeding 28 x 32 ft., and 12 to 14 ft. high, it has been pretty conclusively shown that the best results in the diffusion of heat and air are obtained by introducing the air at a point two-thirds of the distance from floor to ceiling and near one corner, and locating the register for discharge of air on the same side of the room, but near the floor, and near the lower diagonal corner.

Figs. 110, 111 and 112 show the circulation of the air in a small experimental room, with different positions of inlet and outlet. To determine the circulation, one side of the room was made of glass and the air supply was colored.[*]

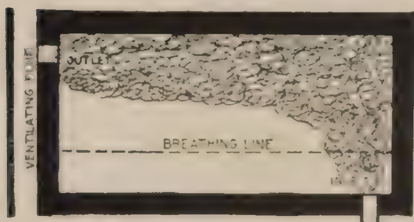


Fig. 110.

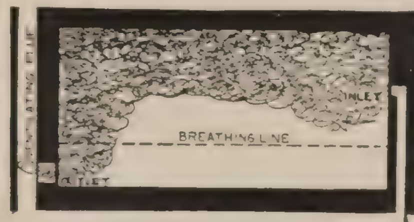


Fig. 111.

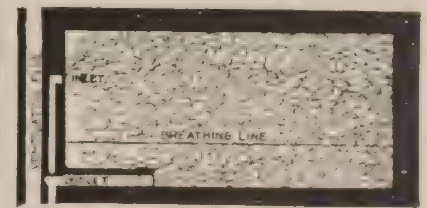


Fig. 112.

"Much better results are obtained by keeping both heat and vent flues in or near an inner wall. As the motion of the air is materially assisted by heat, it is evidently of great advantage that the flues for the supply of fresh air should be kept as warm as possible when an upward current is desired."

In churches, however, there are few interior walls and

*Prof. Carpenter.

*These experiments were made by Warren R. Briggs, Architect, to whom credit is due for the illustrations.

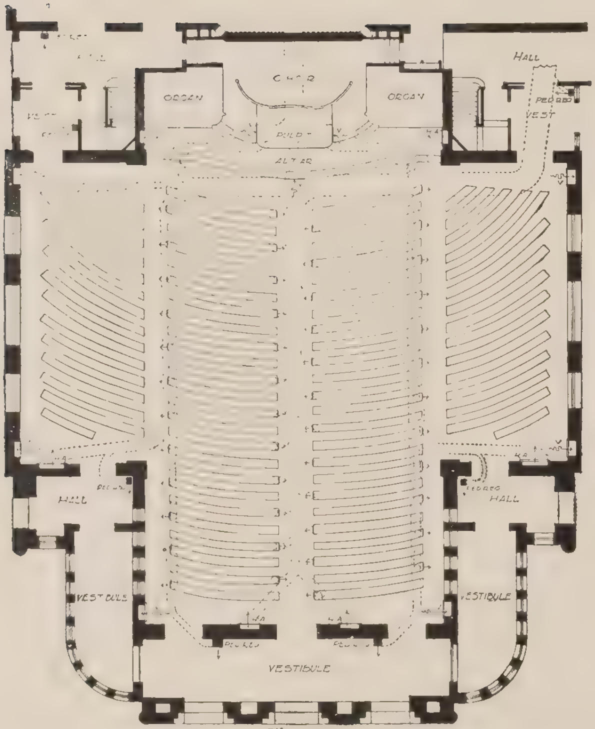


Fig. 113.

the registers must generally be either in the floor or in the outside walls. With the hot blast system of heating the registers, if in the walls, should be at least 8 ft. above the floor to avoid perceptible or unpleasant draughts. In some instances the vertical flues are provided with two registers—one near the floor, to be used when first warm-


Fig. 114.

ing up, and one 8 ft. above the floor, to be used during the service. Large floor registers, with this system of heating are objectional, and should not be used.

A favorite method of admitting the air into large audience rooms is through numerous small registers or

openings of special design placed in the pew ends.

The sides and ends of pulpit platforms are utilized to good advantage, especially where floors are practically level. For halls, vestibules and corridors, pedastal registers seem to be the most satisfactory, especially in inclement weather.

Fig. 113 shows the position of the inlet and outlet registers in the auditorium portion of the Christ M. E. Church, Pittsburg, Pa., Messrs. Weary & Kramer, Architects, and is perhaps as good an arrangement as can be devised, where the basement is finished. It should be noticed that a small inlet register is placed in the end of every other pew, alternating across the centre aisle. The position of the hot air ducts, under the basement ceiling, is shown by the dotted lines.

Fig. 114 shows a special opera chair, with latticed castings for the legs, which are used throughout the Castle Square Theatre, Boston. These legs form a large number of air chambers, to which the air is admitted through small openings in the floor immediately beneath them.

"The air thus passing through the floor openings at relatively high velocity is permitted to escape beneath the persons of the occupants with low and imperceptible movements, and then pass upward to the ceiling vents."

With this arrangement, which is as desirable for a church as for a theatre, it is necessary to use the space beneath the audience room for a large plenum chamber.

When heating by simple indirect radiation or hot air furnaces, without a fan, it is generally necessary to supply the air through a few comparatively large registers.

Fig. 115.

With such methods, the inlet registers should be placed in the side and rear walls, or if this is not practicable, then in the floor near them.

The centre of the room will be warm enough in the coldest weather, if the walls are heated. Where there is a gallery, long slot-like openings should be left in the

gallery floor near the outer walls to permit the heated air to ascend at the back of the gallery, rather than at the front, where it would form a curtain of hot air between the auditors and preacher, and perhaps seriously interfere with the acoustics, as illustrated by Fig. 115.

Admission of Hot Air in Relation to Acoustics:

When a sound wave strikes a current of hot air the latter will seriously interfere with the passage of the sound waves and in some instances to such an extent as to injure the acoustics. For this reason the admission of hot air in large quantities between a speaker or singer and an audience should be studiously avoided. The bad effects of a large register in front of the pulpit, and of heated air ascending in front of a gallery, is shown by Fig. 115.

Position of Outlet Registers. When the air supply is admitted to the room through a large number of small openings either in the floor, pews or chair legs, it is customary to place the ventilating openings either at the top of the walls or directly in the ceiling, but for all other methods of air introduction the outlet openings should be in the walls, near the floor, or in the riser of the pulpit or choir platform. The outlets should be located so that the warmed air must circulate throughout the room before it reaches the vent flues. With any system of heating, however, it is advisable to have a few large openings in the ceiling, controlled by a damper operated from the main floor, to draw off the heated air when the room becomes too hot, but they should not be used for ventilation under normal conditions. With the plenum system of heating the vent ducts may discharge into an open attic, with a central ventilator through the roof. With natural methods of heating the vent ducts should be connected direct with chimneys, or with ventilators on the roof, and proportioned so as to offer as little resistance to an upward draught as possible.

Size of Registers and Air Ducts—Hot Blast System.

The size of registers and air ducts should be determined by the volume of air that is to pass through them and by the velocity. The velocity of the air through the hot air registers or through the vent registers should be reduced to such an extent as to produce no sensible draught in the room. When the inlet registers are 8 feet above the floor, a velocity of discharge of from 350 to 500 feet per minute may be allowed. For floor registers, or those in the walls within 5 feet of the floor, the velocity should not exceed 288 feet per minute. In figuring the size of ordinary register faces, the required area should be increased about 50 per cent., to allow for the grills or pattern.

Example. It is desired to admit 12,000 cubic feet of air per minute into an audience room through six registers placed 8 feet from the floor; what should be the size of the registers?

Ans. 12,000 cubit feet divided between six registers equals 2,000 feet per register. Allowing a velocity of 500 ft. per minute, we must have a net register area of 4 sq. ft. Adding 50 per cent. for fret work, we have 6 sq. ft. as the full register area, which equals a register 24x36 inches.

"To secure a fairly equable discharge through the full area of a screen or register supplied from a vertical flue, the velocity in this flue should not exceed that through the outlet by more than 50 per cent., which gives a velocity in the vertical flues of from 500 to 800 ft. per minute. The rate of flow through the connections to the base of the flues should in turn be higher than that through the flues themselves, while the velocity in the main horizontal distributing ducts would be even higher. In fact, in schools and churches the plan should be to gradually reduce velocities from the point of leaving the fan to the point of discharge to the rooms. Careful investigation has shown that, everything considered, the velocity in the main horizontal ducts from the fan should not be below 1,500 feet per minute, and preferably 2,000 feet per minute."*

Vent or eduction flues and registers should be two-thirds to three-fourths the area of the induction flue and register areas.

Form of Pipes or Ducts. "The most careful attention should be given to the form of the piping or ducts.

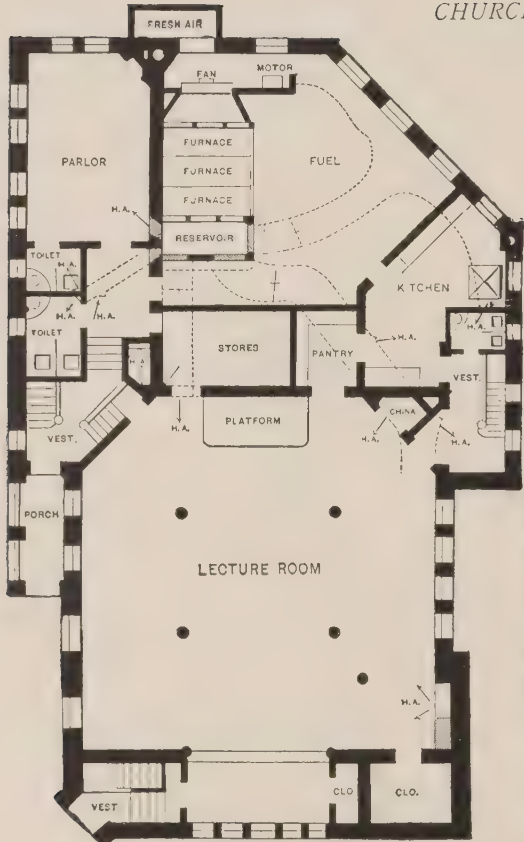
Fig. 116.

Round pipes are the best, square next best, and rectangular pipes should always be made as nearly square as possible.

"No branches should leave mains at right angles, but should branch off at an angle of 45 degrees, with easy radius curves in all cases. No. 90 degree elbow should

*Ventilation and Heating, B. F. Sturtevant Co.

be made with less than seven pieces, or less inside radius than the diameter of the pipe. No. 45 degree elbow should be made of less than four pieces. Each and every branch air duct to flues should have a damper near base of flue, and at every 'Y' in the system of air conduits or ducts there should be placed a regulating damper, as shown in Fig. 116. All these dampers and fenders should be adjustable and fixable at any point within their range of motion. These dampers should be 'set' upon completion of the system at the time of the air test. Hot-air



BASEMENT PLAN.

Fig. 117.

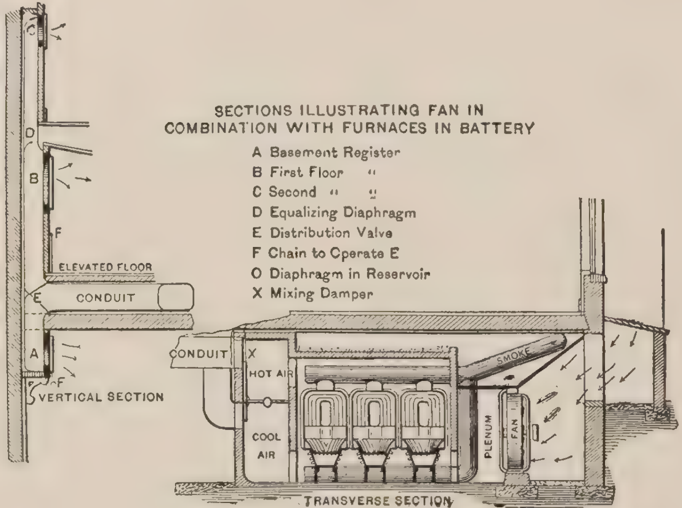


Fig. 118.

pipes, ordinarily, should be covered with one or more coats of asbestos of magnesia covering."*

Fresh Air Intake. With the hot blast system of heating, the intake for the fresh air supply should be some distance above the ground if practicable. In many instances the fresh air is taken in at the top of a high shaft or tower. With ordinary furnace heating or indirect steam radiation, the air is usually taken in through an opening in one of the outer walls just above the ground. When but one inlet is provided, it should be located either in the north or west walls, and preferably in the former.

In order that the system may work satisfactorily at all times, however, it is advisable to provide at least two, and sometimes three inlets, each connected with the heater by a duct, and each duct having a damper, so that either duct may be used at will, but only one at a time.

FORCED BLAST WARMING WITH FURNACES.

While the hot blast system of heating and ventilating, using steam as the source of heat, is probably as nearly perfect as to results as can be expected; yet, for a church of moderate means, it is an expensive system to install, and any system of steam heating requires a competent engineer or fireman, and is often a source of considerable expense for repairs and damages arising from carelessness, leaks, freezing, etc., to say nothing of a possible explosion.

A hot air furnace, on the other hand, is the cheapest heater to install and costs the least for repairs; but, on the other hand, is not very satisfactory when heat alone is depended upon to move the air.

Realizing the economic advantages that might be secured by substituting a battery of hot air furnaces for the steam coils in the ordinary hot blast system, and having a favorable opportunity to test the practicability of such a combination, Mr. George W. Kramer designed and had placed in a church in Akron, Ohio, a system of heating which was essentially like that described under the "Hot Blast System," except that the air was heated by a battery of three hot air furnaces, instead of a bank of steam coils. The church in question was of the combination, pulpit-in-the-corner type and of about 250,000 cubic feet capacity. A description of the apparatus and of its working was given by Mr. Kramer in a paper read at the second annual meeting of the American Society of Heating and Ventilating Engineers, New York, Jan. 21-23, 1896. Fig. 117 represents the basement plan of the church and shows the position of the furnaces and main hot air ducts, and Fig. 118, sections through the furnaces, and vertical ducts. The plenum system of ventilation was employed,

*Buffalo Forge Co.

with a disc fan, driven by an electric motor. The experiment proved to be a success, and the system has since been installed in several churches.

Mr. Kramer says of the first plant: "This apparatus has now been in successful operation for several seasons, with no material changes, two furnaces doing the work under all ordinary conditions, only using the three in severe weather, while in spring and fall one proves sufficient; in this lies the great source of economy. The fan is operated at all times, summer as well as winter, supplying the regular amount of fresh air at the normal temperature or warmed as necessary. There is no complicated apparatus requiring attention or skill more than the ordinary hot air furnace and the turning on of the electric current at the motor, with a little attention to the mixing dampers. A by-pass is provided, so that the air in any principal duct can be changed instantly from hot to cold, or tempered, without affecting the volume." To accomplish satisfactory results with this method, however, requires a different style of furnace from those ordinarily used for house-heating, a furnace with large radiating surface in proportion to the grate area being required and absorption plates to utilize the radiant heat.

CHAPTER IX.

LIGHTING.

THE amount and distribution of glass surface necessary for the proper lighting of any given church is a matter that should receive careful consideration. For day service, with cloudy weather, there should be sufficient light to make it possible to read with ease in any part of the audience room, and the location of the windows, the quality and character of the glass should be such that, with brilliant sunshine, the light will be diffused and not produce unpleasantly lighted or brilliant colored localities. Windows directly behind the preacher should be avoided, unless placed very high, as it is very painful for an audience to face a window. If the room is so large that special lighting is required for the pulpit or choir, it should be provided either from one or both sides or from the ceiling.

In Episcopal churches it is customary to place a window above and behind the altar, but this window is usually so far removed from the pulpit as not to be constantly in the eyes of the audience.

In proportioning the windows it should be remembered that the higher the glass area is placed above the floor, the greater will be its effect in lighting the room; also that windows facing south and east light more brilliantly than those facing north and west. When the principal windows face to the south, it may be necessary to drape them with heavy shades or curtains to subdue the bright sunlight. This is often unavoidable, with such exposures, as the glass area necessary to properly light the room on a cloudy day must necessarily be too brilliant when the sun is shining directly on it, and especially if such windows face the pulpit or choir.

Regarding the glass area required, Mr. Kramer, in his book, "The What, How and Why of Church Building," quotes the following rule: "*Add together the height and depth of the room, one-eighth of the sum will give the aggregate width of opening required, and the square root of the product of the length, height and width will give the area,*" which, however, might only apply under cer-

tain conditions, experience and observation being more valuable in this case than any rule.

When the audience room is lighted mainly by a few large windows, enough small windows should be used to light up the corners of the room which might otherwise be dark and gloomy.

When the church is built on an inside lot, as is sometimes the case in large cities, it will generally be necessary to depend upon skylights for a part of the building. When the skylight is necessary, a glass which will diffuse the light should be used. The best method is by arranging an exterior and interior skylight, the space between being well ventilated and provided with controlling curtains. The exterior skylight should be glazed with a heavy roughened or ribbed glass, and the interior with stained glass, avoiding strong and unpleasant colors.

Artificial Lighting. Except in very small villages, nearly all churches are now lighted in the evening either by gas or electricity. When it can be obtained, electricity is much to be preferred, as it does not contaminate the air as does gas, or produce objectionable air currents. It is always advisable, however, to have a few gas lights, arranged as brackets along the sides of the room and as drop lights in the vestibules, to be used in case the electric current fails.

In lighting by electricity the incandescent lamp should be used, the arc light being only admissible for very large halls, where it can be elevated above the range of vision, and for exterior lighting.

In arranging incandescent lamps in an audience room two quite distinct methods are employed. By the first, the lamps are bunched in groups, either as chandeliers or reflectors, and for the second method, they are distributed over the ceiling and along the gallery front, and sometimes on the truss beams. In this method the lamps are used singly and project but about 3 ins. from the wall or ceiling, the object being to light the room uniformly, without the presence of any strong lights to catch the eye.

This latter method requires a greater number of lamps and consumes more electricity to give the same intensity of light at the floor level than the first, but, in the opinion of many, is much more pleasing and comfortable to the eye.

When lighting by this method, all sockets not more than 15 feet above the floor may be stationary, but those on the ceiling should be fastened to wooden plugs set in holes in the ceiling, so that they may be drawn up into the attic for replacing or cleaning the lamps.

When gas is used for lighting, chandeliers must be used for lighting the central portion of the audience room.

For chandeliers those of the reflector type are undoubtedly the most desirable, the great advantage of the reflector being that it can be hung high enough to be out of the range of vision, while at the same time it throws a clear, even light downward and over the audience at a minimum of expense for gas or current.

With either method of lighting a few brackets should be arranged around the sides of the room.

Number of Lights Required. The author has been unable to find any accepted rule for the number of lights required for lighting a given space, as the number depends as much upon the position of the lights as upon the size of the room.

The following data, however, may be of some assistance to the Architect in determining the number of lamps or gas jets required:

An ordinary chandelier placed 12 ft. above the floor, with 12 3-ft. gas burners, will light an area 30 ft. in diameter.

The same lights in a Frink reflector, placed 16 ft. above the floor will light an area 35 ft. in diameter.

A 16-candle-power lamp gives about the same intensity of light as a 3-ft. gas burner.

The audience room, Plate XXIII., is well lighted by 98 ceiling lights, 25 gallery lights and 26 bracket lights, all 16-candle power electric lamps.

The audience room, Plates LI. and LII., is lighted by 134 ceiling lights, 18 lights on gallery front and 20 bracket lamps, besides pulpit and organ lamps, all 16-candle power.

Trinity M. E. Church, Denver, has an audience room 100 ft. deep, 84 ft. wide, 43 ft. high, with a panelled ceiling, and wide gallery on three sides. It is lighted by 382 electric lamps, placed as follows: On the ceiling, 29 24-candle power lamps and 33 16-candle power lamps; on the frieze below ceiling, 142 lamps; on the gallery front, 80 lamps; on organ arch, 53 lamps, and 36 lamps in wall brackets, all 16-candle power except the 38 24-candle power on the ceiling. There are rather more lamps than are needed for lighting the space, although the effect is very fine.

A special light should be provided for the pulpit and organist, with outlet through the floor.

Valves and Switches. The control of the lights in a church is a matter of considerable importance.

A few lights, such as vestibule lights, one or two brackets in the audience and lecture rooms, pulpit and organ lights and the lights in small rooms, should be on the general circuit or main gas pipe. All other lights

should be controlled by switches if electricity is used, or by stop valves if gas is used. Valves or switches for controlling the lights in the audience room should preferably be placed in a cabinet in the wall of the room near one of the doorways. With gas, four fits or stop-cocks will generally answer for a church of moderate size, one for the ceiling lights in audience room, one for the bracket lights, one for the lecture room lights, and a general fit for the balance of the lights.

With electricity, four or five switches should be provided for the audience room, and two for all rooms having more than four lamps. These switches should be arranged so as to control alternate lights—for example, two switches for ceiling lights, two for gallery lights and one for wall brackets. If large chandeliers are used, each chandelier should be controlled by two switches, so that either half or all of the lights may be used at will. Two, or even three chandeliers may be controlled by the same switches.

Having the lamps controlled in this way will considerably reduce the cost of lighting, as the full number of lights need be used only during the service, one-half the number being usually sufficient for lighting before and after the service.

CHAPTER X.

CHURCH BELLS.—TOWER CLOCKS.

CHURCH BELLS. "It is surely to be regretted that church bells are going out of fashion. Though often harsh and unmusical, they come nearer to pealing sweetness than any others. Fortunately, they still ring in country towns; and what can be more soothing to the perturbed spirit than a chorus of bells on a Sunday—a cool, still morning in early autumn, it may be? There is a Sabbath hush over everything and a charming inexplicable odor of yellowing leaves in the air, and, perchance, a peaceful, clean-shirted calm in the household. Then out of the solemn stillness comes the first peal of the first church bell, near at hand, perhaps, deep, sonorous, resounding, the metallic clang of every stroke dying away in tremulous waves of music. Between two strokes breaks in the peal of another bell, lighter of metal and farther away, a tenor to the big one's bass. Another and another join the chorus, till presently half a dozen bells in different parts of the little town contribute their brazen appeals to the clamorous melody, and the air resounds with the chance chimes. If there be no bell of dreadful harshness among them, the chorus is most exquisitely soothing, a quietus to the 'restless pulse of care,' an irresistible call to worship and to prayer.

"But a hard-throated bell in a steeple is as much an atrocity as a hard-hearted preacher in the pulpit. How can sinners be expected to come to repentance to the calling of a bell that has a 'melancholy menace in its tone?' An old heathen in an Ohio town used to say that the Methodist church bell had only two words in its vocabulary, and that it was forever calling the names of two pious church leaders—'Mor-gan, Swan-son, Mor-gan, Swan-son, Mor-gan, Swan-son.' Had the bell been less harsh of tone, he might have heard it saying: 'Come, ye sinners, poor and needy!' And yet, like many other sounds and sights, the voices of the bells find varied interpretation according to the state of the listener's own heart and soul:

> " 'One sound to all, yet each
> Lends a meaning to their speech,
> And the meaning is manifold.' "

Of bells it can with truth be said that ever since their introduction they have been highly regarded by all nations, the Turks alone excepted. Certainly there is noth-

ing of simple human contrivance for which a community in any locality has stronger regard or with which associations are more deeply mingled. And there is that in the associations connected with bells which has caused them to be considered by the people of nearly every nation, as not inappropriate memorials to departed relatives and friends. It is a very common practice to place inscriptions upon church bells, either giving the name of the donor or some religious sentiment.

Church bells are usually mounted by the manufacturers with a wheel and rotary yoke upon a wooden frame with iron standards. They should also be provided with a *tolling hammer.* The price of a bell is computed by the pound, the mountings being an additional charge. For the best quality of bells the price at the factory (in 1895) is about 26 cents per pound. This price, however, is subject to considerable fluctuation, owing to the variations in the price of the metals of which they are composed. The following table gives the diameter and size of mountings for bells weighing from 400 to 2,000 pounds.

BELL.			MOUNTINGS.		
Weight.	Medium Tone.	Diameter.	Size of Frame—Outside.	Diameter of Wheel	Price of Mountings.
400 lbs.	D	27 in.	3 ft. 6 in. by 3 ft. 6 in.	4 ft. 4 in.	$30
450 "	C#	28 "	3 ft. 6 in. by 3 ft. 6 in.	4 ft. 4 in.	30
500 "	C	29 "	3 ft. 9 in. by 3 ft. 11 in.	4 ft. 9 in.	35
550 "	C	30 "	3 ft. 9 in. by 3 ft. 11 in.	4 ft. 9 in.	35
600 "	B	31 "	3 ft. 9 in. by 3 ft. 11 in.	4 ft. 9 in.	35
700 "	B	33 "	4 ft. 0 in. by 4 ft. 0 in.	5 ft. 6 in.	40
800 "	B♭	34 "	4 ft. 0 in. by 4 ft. 6 in.	5 ft. 6 in.	40
900 "	A	36 "	4 ft. 6 in. by 4 ft. 6 in.	5 ft. 9 in.	45
1000 "	A	37 "	4 ft. 6 in. by 4 ft. 6 in.	5 ft. 9 in.	45
1100 "	A	38 "	4 ft. 6 in. by 4 ft. 11 in.	5 ft. 9 in.	45
1200 "	A♭	39 "	4 ft. 8 in. by 4 ft. 11 in.	6 ft. 3 in.	55
1300 "	A♭	40 "	4 ft. 8 in. by 4 ft. 11 in.	6 ft. 3 in.	55
1400 "	G	41 "	5 ft. 0 in. by 5 ft. 0 in.	6 ft. 6 in.	70
1500 "	G	42 "	5 ft. 0 in. by 5 ft. 0 in.	6 ft. 6 in.	70
1600 "	G	43 "	5 ft. 0 in. by 5 ft. 0 in.	6 ft. 6 in.	70
1800 "	F#	45 "	5 ft. 5 in. by 5 ft. 8 in.	7 ft.	90
2000 "	F	46 "	5 ft. 5 in. by 5 ft. 8 in.	7 ft.	90

For a village church a bell weighing 800 to 1,200 pounds should serve its purpose. For a large city church a bell weighing about 3,000 pounds is desirable.

The *bell chamber* should not be placed any higher in the tower than is necessary to bring the position of the bell, when mounted, just above the ridge of the roof, or the level of the tops of the surrounding houses. This room should be especially arranged to permit the free egress of the sound waves. It should be tightly ceiled directly above the tops of the windows, which latter should be as wide and nearly open as possible, and should be extended almost to the floor, in order that the bell, when at rest,

may have its mouth above the level of their base. The floor beneath the bell should also be covered with tin, copper or canvas, like a roof, and should have a slight pitch toward one corner, with an outlet for the water that may penetrate the chamber.

Chime and Peal Bells.

There is no limit to the number of bells necessary to constitute a chime or peal, except that which is suggested by the necessarily constant decrease of weight and the consequent shrillness of tone; but in this country a *chime* is generally said to consist of eight bells, attuned to the eight tones of the octave. In nearly every case, however, a bell attuned to the flat seventh tone of the scale is added, inasmuch as the chime is thus rendered capable of producing music in two keys. The number of *changes* which can be played upon a chime of bells is almost marvelous, twelve bells allowing a no less number than 479,091,600.

A *peal* in this country is generally said to consist of three bells, attuned to the first, third and fifth tones of the musical scale, or four bells, the eighth musical tone being thus added. These bells are usually furnished with full mountings, and are sounded by swinging in the manner of church bells.

The quality of a bell depends upon the nature of its composition, and equally as much upon its shape and the proper proportions of its height, width and thickness. The only metals capable of producing a proper ringing alloy are copper and tin.

The tone of a bell, it is well known, is the result of vibrations. When struck a bell changes shape, and these repeated changes constitute its vibrations. The number of vibrations produced in a bell in a given time varies, directly as the square of the thickness, and inversely as the bell's diameter, or as the cube root of its weight. In a number of bells forming a complete octave the diameters would appear in the following proportions: C 1, D 8-9, E 4-5, F 3-4, G 2-3, A 3-5, B 8-15, C 1-2.

TOWER CLOCKS.

As clocks are sometimes placed on church towers, especially in villages, a few words as to the requirements of space, size of dial and general arrangement may be found useful.

A tower clock consists of the movement or mechanism which controls the hands, and operates the bells, if a striking clock, the connecting rods which connect the movement with the hands, the weights which give the motion to the mechanism, the pendulum which regulates it and the hands and dials which indicate the time to the

public. An hour clock strike also has one bell, which is struck by a hammer, operated from the movement by

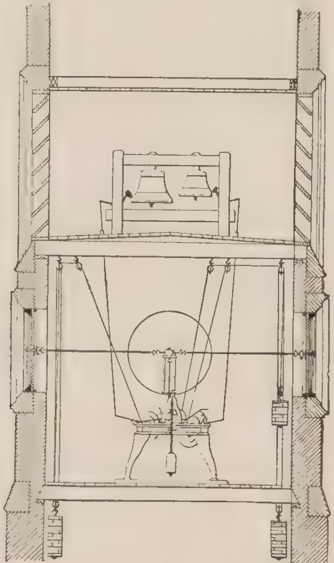


Fig. 119.

means of cords and levers. A quarter strike clock is usually provided with two bells, selected to harmonize, and of sufficient difference in weight and tone to distinguish the quarter from the hour bell. Sometimes four bells are used as quarter-hour bells, and a larger bell is used for the hour bell. To ring the notes of the Cambridge or Westminster quarters requires four bells. A fifth may be added for the hour striking.

The movement requires a separate "train" to run the hands, one to strike the hours and a third to strike the quarters; hence a striking clock requires more mechanism and a larger frame than one that does not strike.

The dials should be below the bell deck, in the tight portion of the tower, and the bells above the deck, as described under "Bells."

The general arrangement of the mechanism of a striking clock is shown by Fig. 119.

The movement, however, can as readily be placed in a room below the dials, and in some respects this is a better arrangement, as there is less vibration in the lower part of the tower. The movement frame for an eight-day clock, with one dial 5 ft. in diameter, or four dials 3 ft. in diameter and without bells, occupies a space 14 ins. wide, 14 ins. deep and 55 ins. high, and weighs, boxed, about 500 pounds. For the same dials, but with hour strike, the frame measures 36 ins. wide, 25 ins. deep and 54 ins. high. For an eight-day clock, with one dial up to 8 ft., or four

dials 7 ft. or less, and for quarter strike with peal of bells, the frame measures 79 ins. wide, 41 ins. deep and 60 ins. high and weighs about 2,300 pounds. For very large dials and bells a movement is made which measures 104 ins. wide, 42 ins. deep and 75 ins. high.

DIALS. "To look well and show plainly, dials should be 1 ft. in diameter for every 10 ft. of elevation and should set out flush with or close to the line of the building or tower."*

Dials may be made of wood, galvanized iron or glass, or a skeleton dial of wrought iron standing out in front of the wall or spire may be used.

Wood dials should be made of two thicknesses of well-seasoned pine, about 4 ins. wide by ¾ in. thick, with the edges tongued, grooved and painted before putting together. The two thicknesses should be firmly screwed or nailed together, with the grain crossing, smoothed and painted over, and the outer face smalted. The paint used in the joints should be of the same color that the face is to be, so that the joint will not show in case of shrinkage. The joints in the face side of the dial should be vertical, so that rain will not lodge in them. A moulding is generally put around the face of the dial to give a finish.

For conveniently getting at the hands at any time from inside the tower there should be a piece from 12 to 14 ins. square cut from each dial plate, with the lower edge about 4 ins. above and directly over centre of dial. This piece can be beveled at top and bottom to keep the rain out, and a cleat should be screwed on the inside to keep it in place. If the room be dark, one of these openings can be glazed to give light. The numerals and dots are generally made of cast metal and furnished by the clock-maker.

Iron dials can be made of heavy galvanized iron, with a wood backing, an inch or more thick, the full size of the dial. The numerals can be painted on the dial or metal numerals may be screwed on.

Glass dials should be made of heavy plate glass, ground on both sides, and the numerals painted on. Up to 6 ft. in diameter the dial may be made of one piece of glass, but for any greater diameter it is best to make the dial in sections.

Skeleton dials may be varied in design and made of either cast or wrought iron. Eperience, however, has shown that it is best to leave the centre of the dial entirely clear.

"Skeleton dials should not be placed more than 2 or 3 ins. from the face of the wall, as they require a backing to show to the best advantage."

*Seth Thomas Clock Co.

The color of the dials and hands should be considered in connection with the color of the wall or background, with a view to obtaining the best contrast.

When illuminated dials are used, an automatic attachment to the clock can be added which will turn the light on or off (gas or electric) at the hours desired.

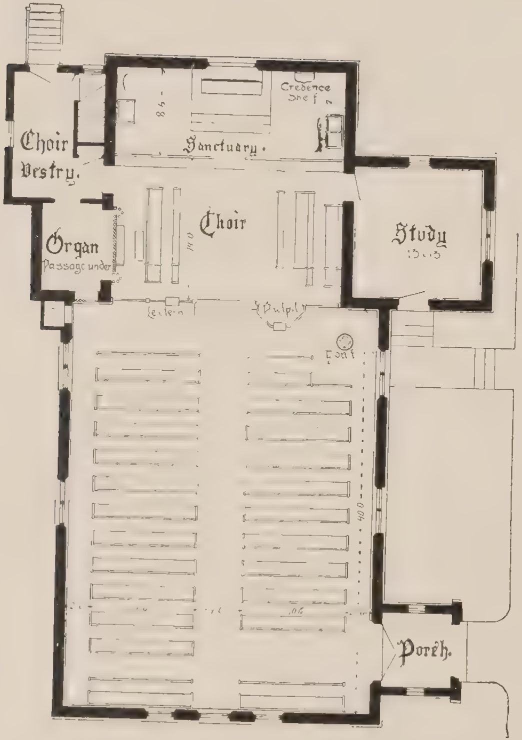
For further information concerning tower clocks the reader is referred to the Seth Thomas Clock Company, Thomaston, Conn.

Electric Clocks and Bells. Owing to the fact that only a very small percentage of the people, especially in a city, can be in a position to see the dials of a tower clock, while many can benefit by hearing the hour struck by the bells, the latter are, as a rule, of more direct benefit than the dials, except, perhaps, in villages, and there both are desirable.

By means of recent inventions, a bell in the tower may now be struck electrically by connection with a small wall clock, and even chimes can be automatically operated by electric action, the music being arranged on small wooden cylinders with pins which strike against a special keyboard. The cylinders may be changed as often as desired. Clocks are now arranged to operate by electricity, so that the dials may be on the tower and indicate the time, while the clock may be in any part of the church or in some other part of the city. Any number of clock dials may be placed in the various parts of the church, and the hands operated by electrical connection from some central clock, which may be in the churches or at some central station in the city. In the larger cities there are companies which put up clock dials wherever desired and operate them from a central clock which is maintained absolutely correct. A great advantage of electric clocks, regulated from a central clock, is that all of the dials indicate the same time.

PLANS AND VIEWS OF CHURCHES.

The following plans, exterior and interior views and sections are given more to illustrate different arrangements of plan and interior treatment than as models of Architectural design. Nearly every desirable arrangement is here illustrated with a considerable variation in size and cost. With few exceptions they represent churches designed within the past ten years and are therefore strictly modern.



PLAN AND PERSPECTIVE OF SMALL EPISCOPAL CHURCH.
Seating capacity, 160 to 200. Cost in brick, about $4,000.

F. E. KIDDER, Architect.

DESIGN FOR AN EPISCOPAL CHURCH

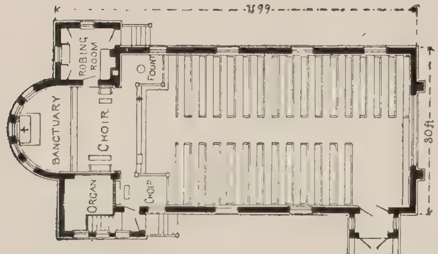
Width of lot [illegible] feet extreme length of building 116 feeet.

KIDDER & WIEGER Architects

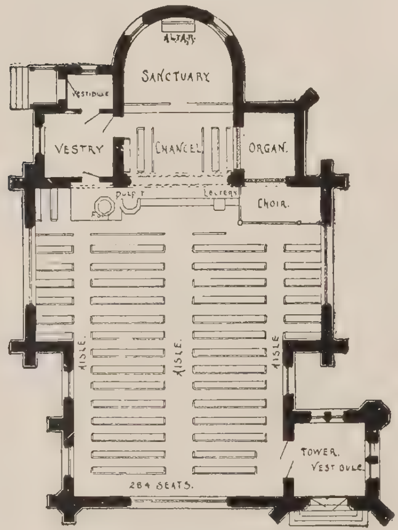
PERSPECTIVE VIEW, DESIGN **F.**

These designs are for small Episcopal churches costing from $3,000 to $12,000. The seating capacity of Plan F is 284, and of Plan G, 220. Plan F can be considerably enlarged without changing the design.

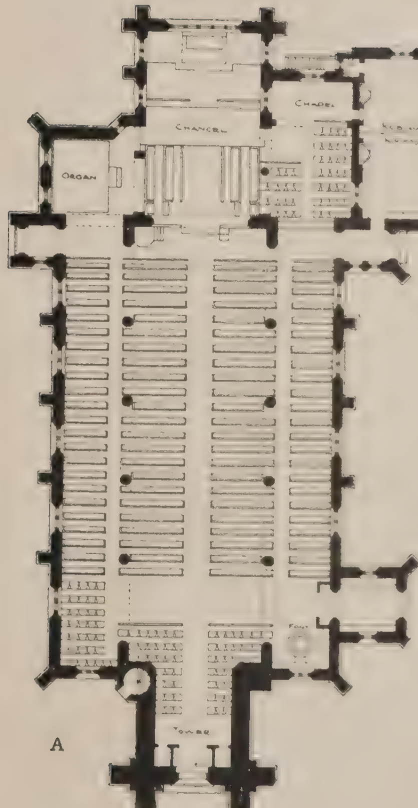
F. E. KIDDER, Architect.



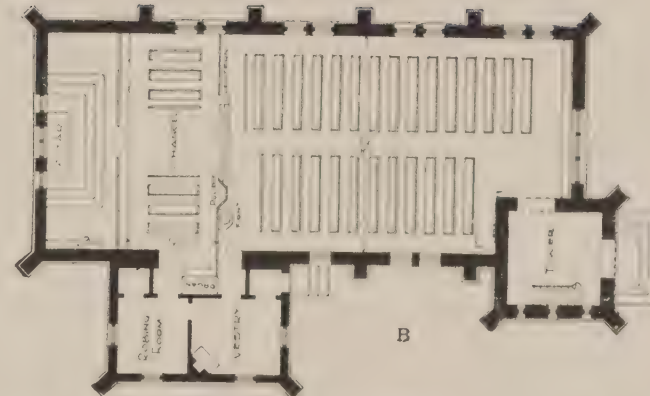
DESIGN **G.**



DESIGN **F.**



A



B

C

A—PLAN OF ST. MARK'S CHURCH, HARROGATE, ENGLAND.

B—CHURCH AT EDGEWATER, ILL. HENRY IVES COBB, Architect.

C—CHANCEL OF GRACE CHURCH, ELMIRA, N. Y. HENRY M. CONGDON, Architect.

DESIGN H.

Extreme dimensions, 100x207 feet. Cost, $90,000 to $200,000.
Seating capacity: church, 1,900; chapel, 350.

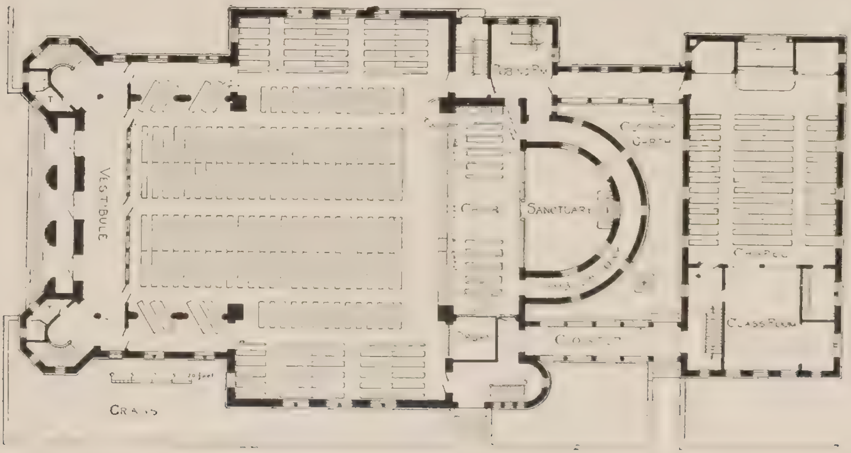
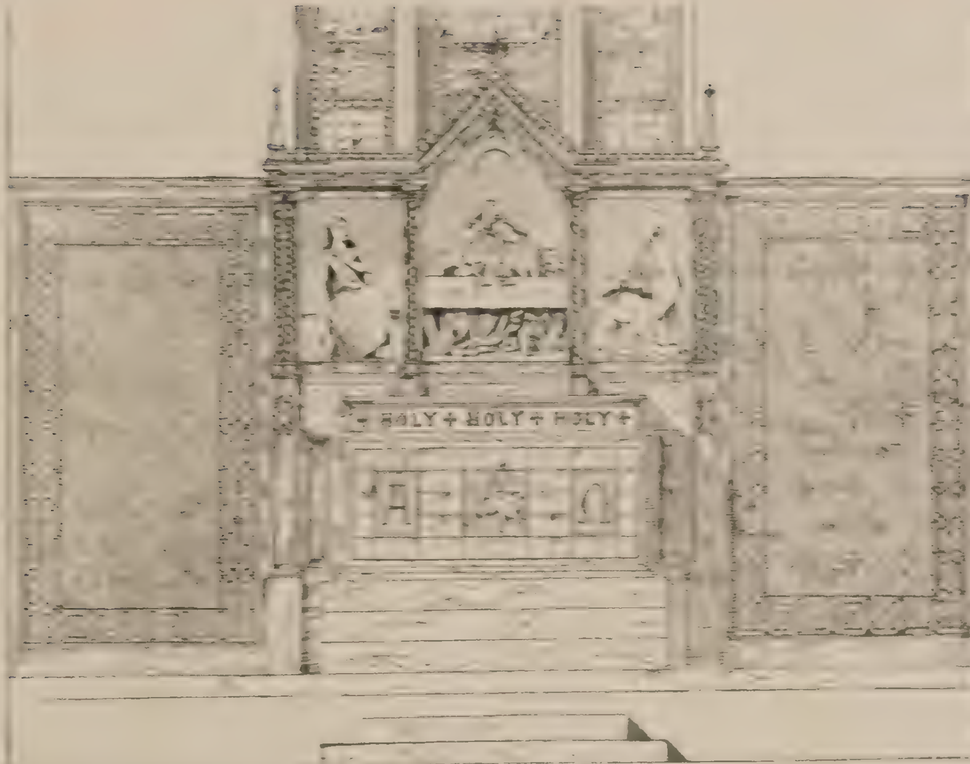


PLATE VI.



ALTAR AND RE-REDOS. ST. JOHN'S CHURCH, NORTH ADAMS, MASS.

A [illegible] Designed and executed by J. & R. LAMB, New York.

PLAN OF

TRINITY CHURCH, BOSTON, MASS.

(Before the addition of the porch.)

H. H. RICHARDSON, Architect

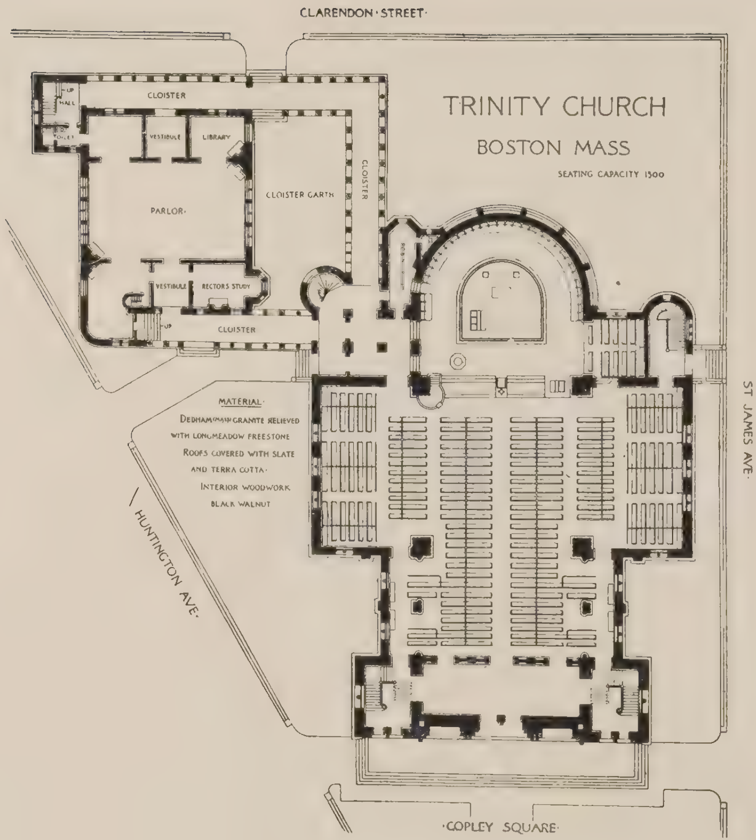
By permission,

The American Architect and Building News Co.

Built in 1876-7, at a cost of $750,000.

Extreme width of church across the transepts is 121 ft., and the extreme length 160 ft. The tower is 46 ft. square inside.

The Sunday School occupies the second story of the building at the left.



TRINITY CHURCH, BOSTON, MASS., AS ALTERED BY SHEPLEY, RUTAN & COOLIDGE, ARCHITECTS.

AN ENGLISH COUNTRY CHURCH.

Reproduced from large print in English Country Churches, by permission, BATES & GUILD Co., Publishers.

CHURCH AT RADLEY, ENGLAND

Reproduced from large print in English Country Churches, by permission, BATES & GUILD CO., Publishers.

PLATE XI.

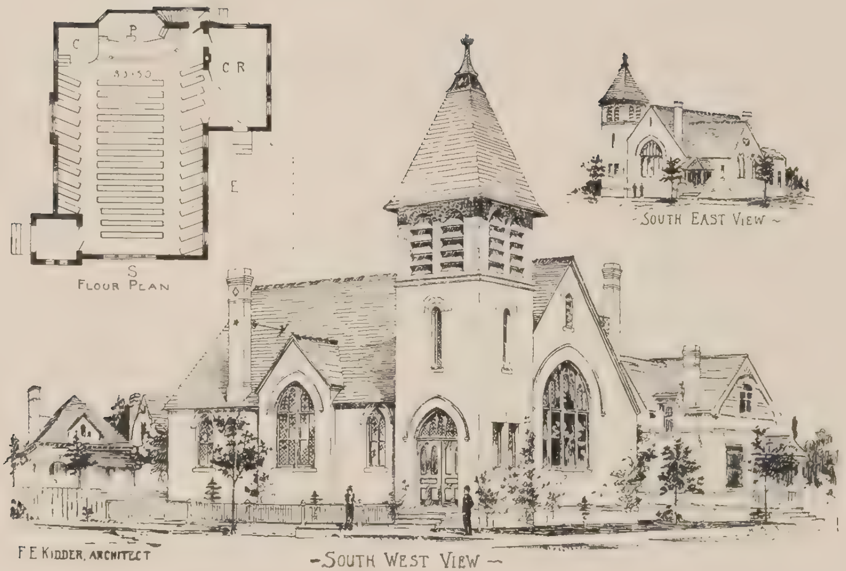
CHURCH OF OUR SAVIOUR, MIDDLEBORO, MASS.

CRAM, WENTWORTH & GOODHUE, Architects.

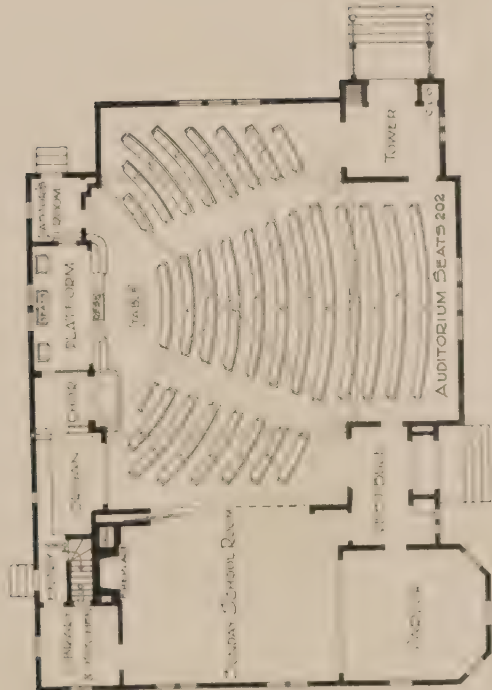
PERSPECTIVE AND PLAN, CONGREGATIONAL CHURCH AT HIGHLAND LAKE, COLO.

Frame Church, built in 1896. Cost $1,600.

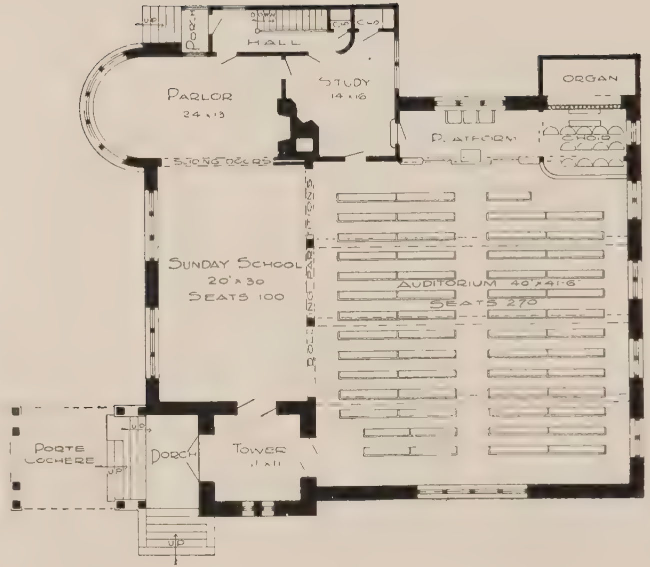
F. E. KIDDER, Architect.



Design for Methodist or Lutheran Church, to seat 300. Main building, 35x53 ft. Tower, 11½ ft. square, and 56 ft. high to top of finial. The room C. R. was intended for week day Kindergarten. A Sunday school addition can be built on at E. Cost in frame, about $2,500; in brick, $3,000 to $5,000.



Design by STEPHENSON & GREEN, Architects.



DESIGN FOR VILLAGE CHURCH.

To seat from 300 to 400 people.

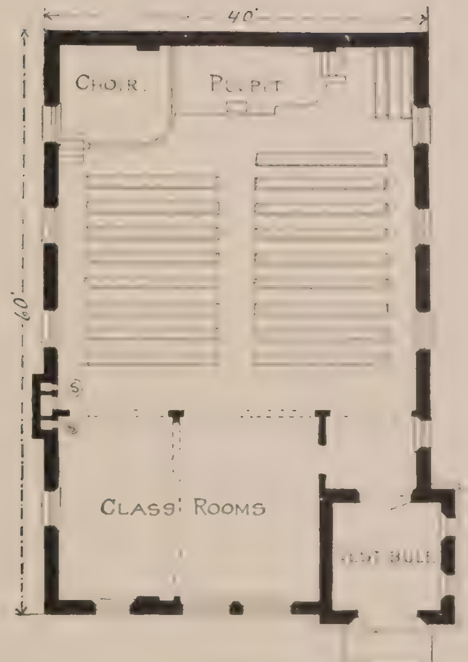
After a design by STEPHENSON & GREENE, for church at Carmel, N. Y

PERSPECTIVE VIEW.

FIRST CONGREGATIONAL CHURCH, LYONS, COLO.

Erected 1894.

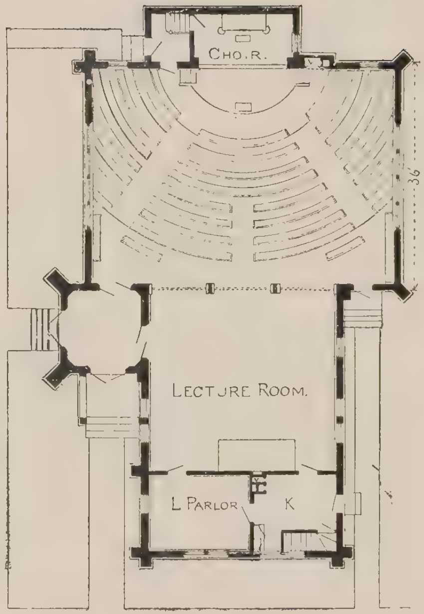
Built of local stone, with shingle roof; no basement. Cost, $3,000.
180 sittings in pews; 110 sittings in chairs.



FLOOR PLAN.

F. E. KIDDER, Architect.

PERSPECTIVE VIEW.



FLOOR PLAN.

FIRST CONGREGATIONAL CHURCH, LONGMONT, COLO.

Erected 1894. F. F. KIDDER, Architect.

Built of brick, with stone foundation and trimmings, shingle roof Cost about $6,000. Seating capacity of audience room, 260 ; size of room, 34x48 feet. Seating capacity of lecture room, 120 Extreme dimensions of building 59x98 feet.

PERSPECTIVE VIEW.

FLOOR PLAN.

DESIGN A

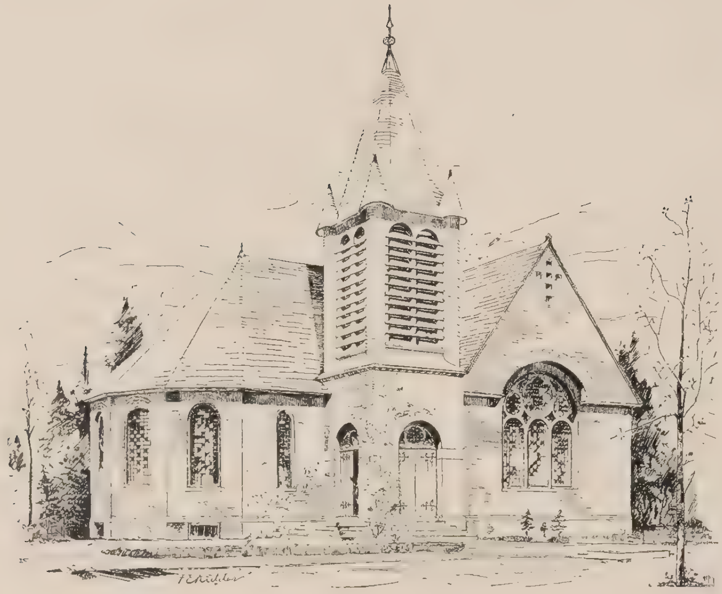
F. E. KIDDER, Architect.

Brick with stone trimmings, shingle roof, Cost, $4,000 to $5,000.

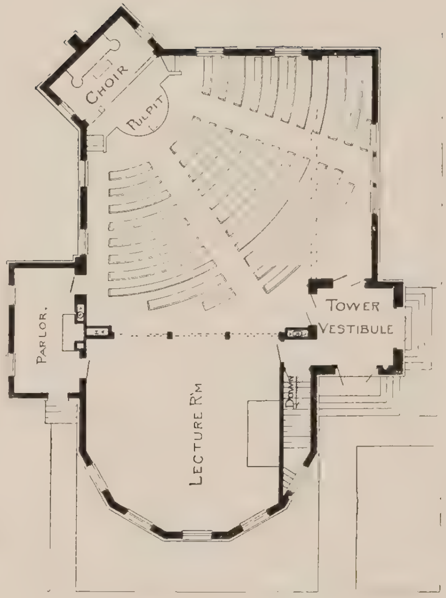
Seating capacity: pews, [illegible]; [illegible] ladies' parlor, 40.

Height of walls above floor, 12 feet; height of ceiling, 19 feet 6 inches; height of [illegible] sidewalk, 41 feet.

This is a very desirable arrangement for a small Congregational church or chapel.



PERSPECTIVE VIEW.

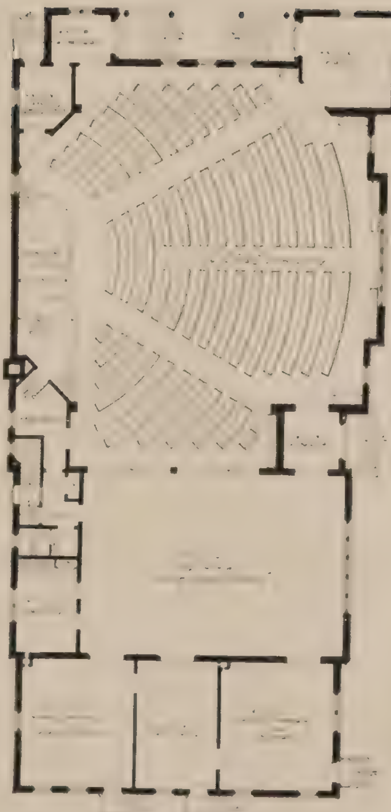


FLOOR PLAN.

DESIGN B.

F. E. KIDDER, Architect.

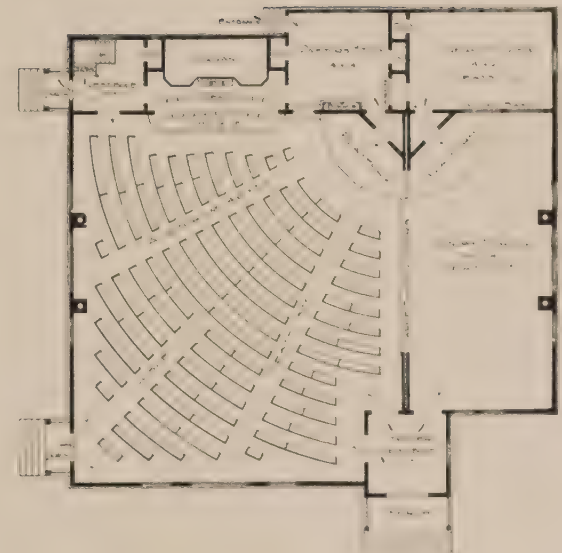
Brick, with shingle roof and gables and shingle tower, or could be built with wood frame and veneered with brick. Cost, $4,000 to $6,000. Seating capacity: audience room, 250; lecture room, 120. Inside dimensions: audience room, 42x43 feet; lecture room, 29x29 feet; parlor, 10x19 feet. Extreme dimensions, 65x83 feet.



PLAN OF PLYMOUTH CONGREGATIONAL CHURCH WICHITA, KANSAS.

Built in 18[illegible] F. E. KIDDER, Architect

Brick veneer. Cost, [illegible]

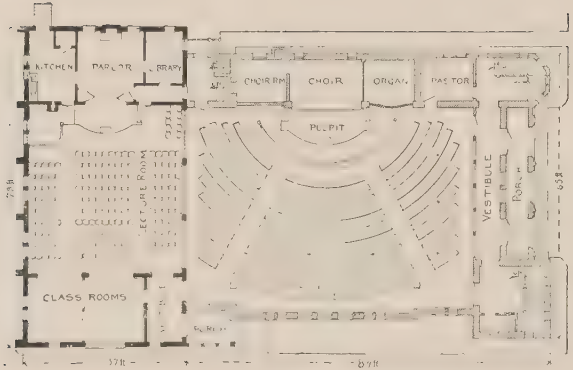


PLAN OF FIRST PRESBYTERIAN CHURCH, QUINCY, MASS.

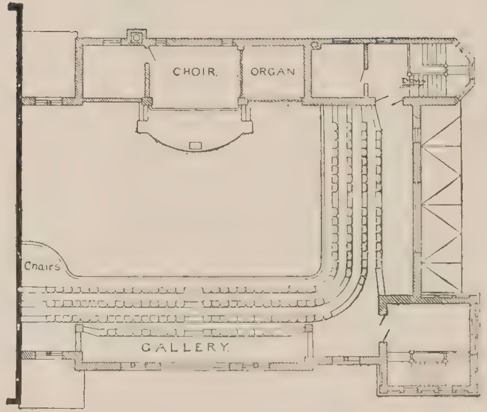
L. B. VALK & SON, Architects.

A good arrrangement for small church with pulpit in the corner.

Suitable for frame or brick.



FLOOR PLAN.



GALLERY PLAN.

PROPOSED SIMPSON M. E. CHURCH DENVER, COLO.

F. E. KIDDER, Architect.

Brick, with stone trimmings. Estimated cost, $16,000 to $20,000. Seating capacity: pews, 406; gallery, 220; lecture room and class rooms, 280. Inside dimensions of audience room, 46x66 feet. The lecture room wing (with solid brick walls) was built in 1889; the church proper shown by etched lines is not yet built. This is an excellent working plan for a church having an average congregation of about 600. For extra occasions 800 people can be seated. The entrances and stairways are ample and well located, and the social features of the church are well provided for.

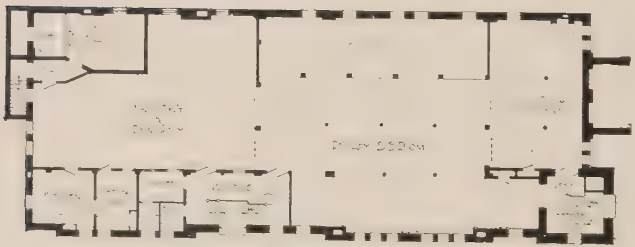
DESIGN FOR

SIMPSON M. E. CHURCH,

DENVER, COLO.

F. E. KIDDER, Architect.

PLAN OF MAIN FLOOR

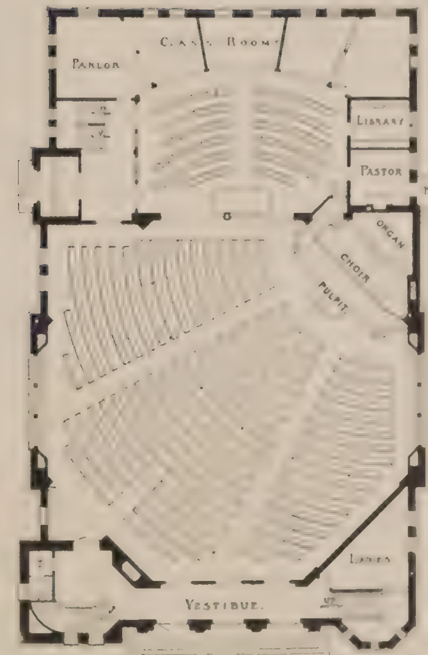


PLAN OF BASEMENT FLOOR

This church is built of pressed brick with stone trimmings, and cost $18,500 exclusive of furnishings. Extreme dimensions, 50x128 feet. Size of Audience room 47x62 feet. S ating capacity : pews, 355 ; galleries, 228 ; lecture room and ladies' parlor, 320. Basement affords accommodation for 500 children. Main floor 5 feet above sidewalk at corner. Building heated by steam.

BOULEVARD CONGREGATIONAL CHURCH.
DENVER, COLORADO.

Erected 1895. F. E. KIDDER, Architect.

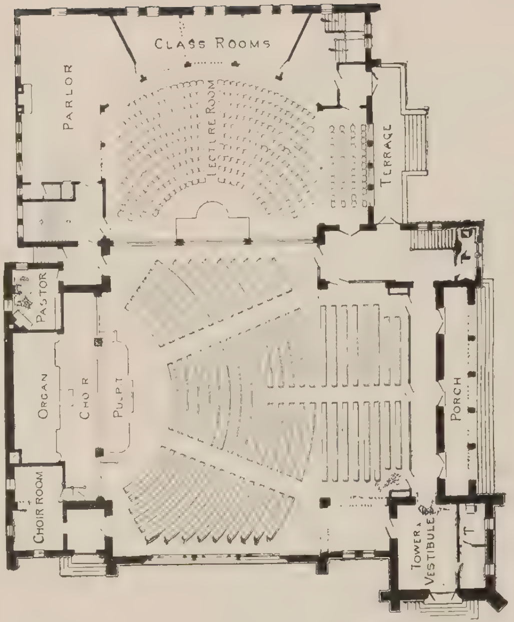


FLOOR PLAN

Design C. F. E. KIDDER, Architect

Audience room 70 feet square. Total accommodation about 1,300. Estimated cost, brick $10,000; Stone

PERSPECTIVE VIEW.



FLOOR PLAN.

DESIGN D.

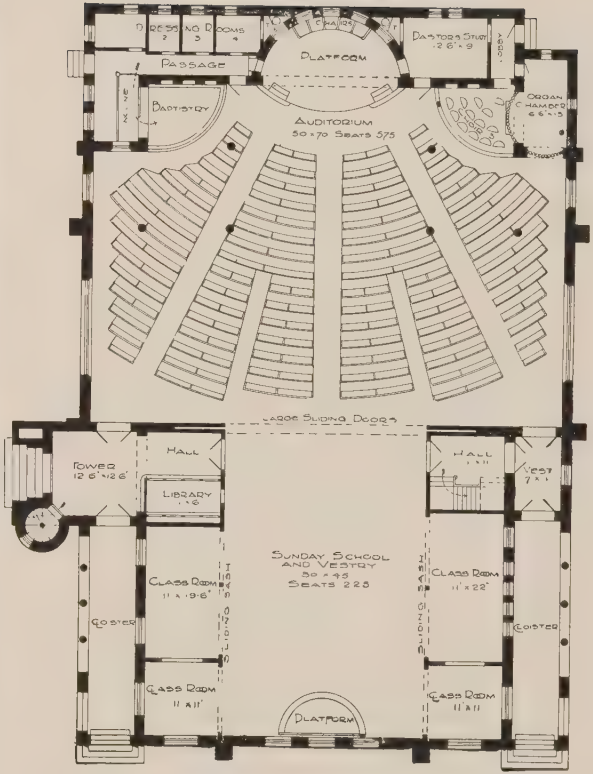
F. E. KIDDER, Architect.

A very desirable arrangement for a large church. Cost in stone about $90,000. Seating capacity : pews, 800 ; gallery, 250 ; total capacity for preaching service, 1,600. Extreme dimensions, 125x154 feet. This design can be adapted to a smaller size.

FIRST PRESBYTERIAN CHURCH, BOULDER, COLO.

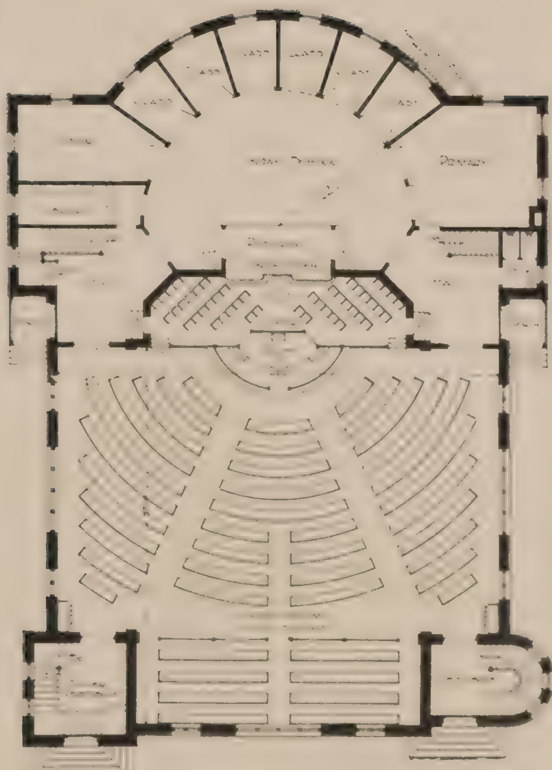
Built in 1895. Pressed brick. Cost about $12,000.

VIEW FROM PULPIT PLATFORM.

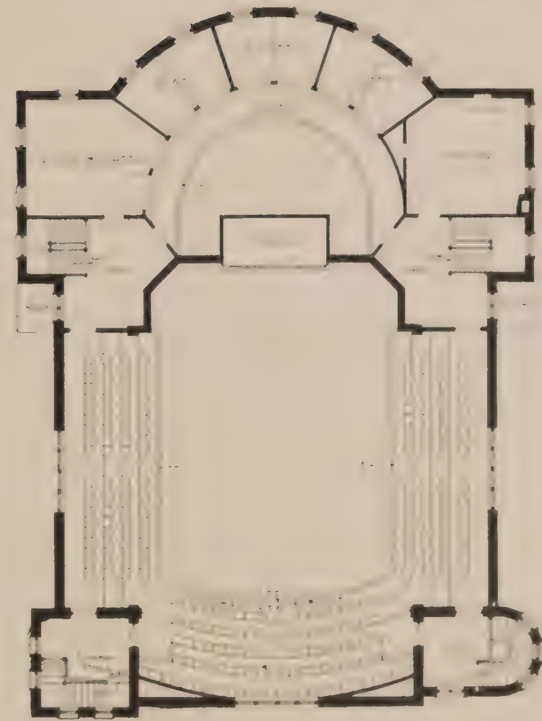


PLAN AND INTERIOR VIEW OF FIRST BAPTIST CHURCH, COLORADO SPRINGS, COLO.

L. B. VALK & SONS, Architects.

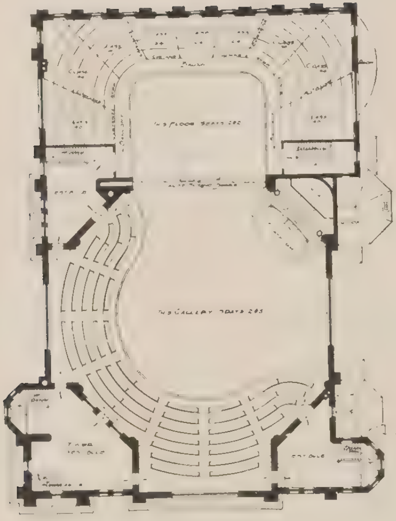


FIRST FLOOR

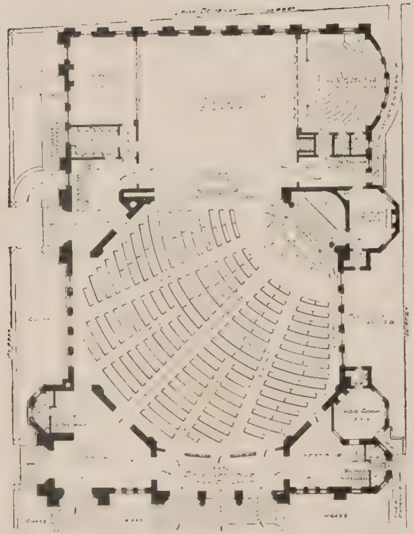


GALLERY

Plans for church to seat from 700 to 800, with [illegible]



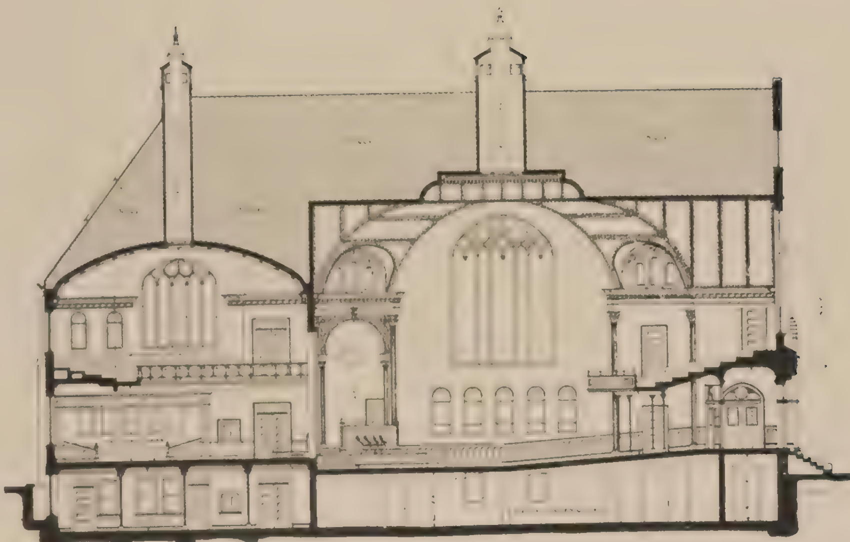
PLAN OF GALLERY AND 2ND FLOOR, SUNDAY SCHOOL



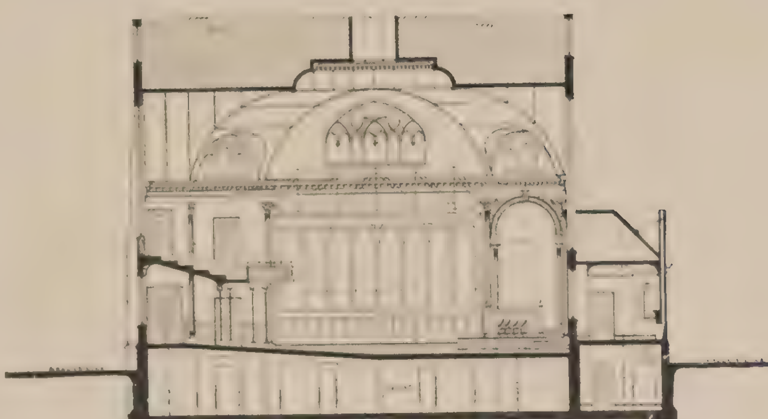
PLAN OF MAIN FLOOR

FIRST REFORMED CHURCH, PASSAIC, N. J.

L. B. VALK & SON, Architects.



LONGITUDINAL SECTION

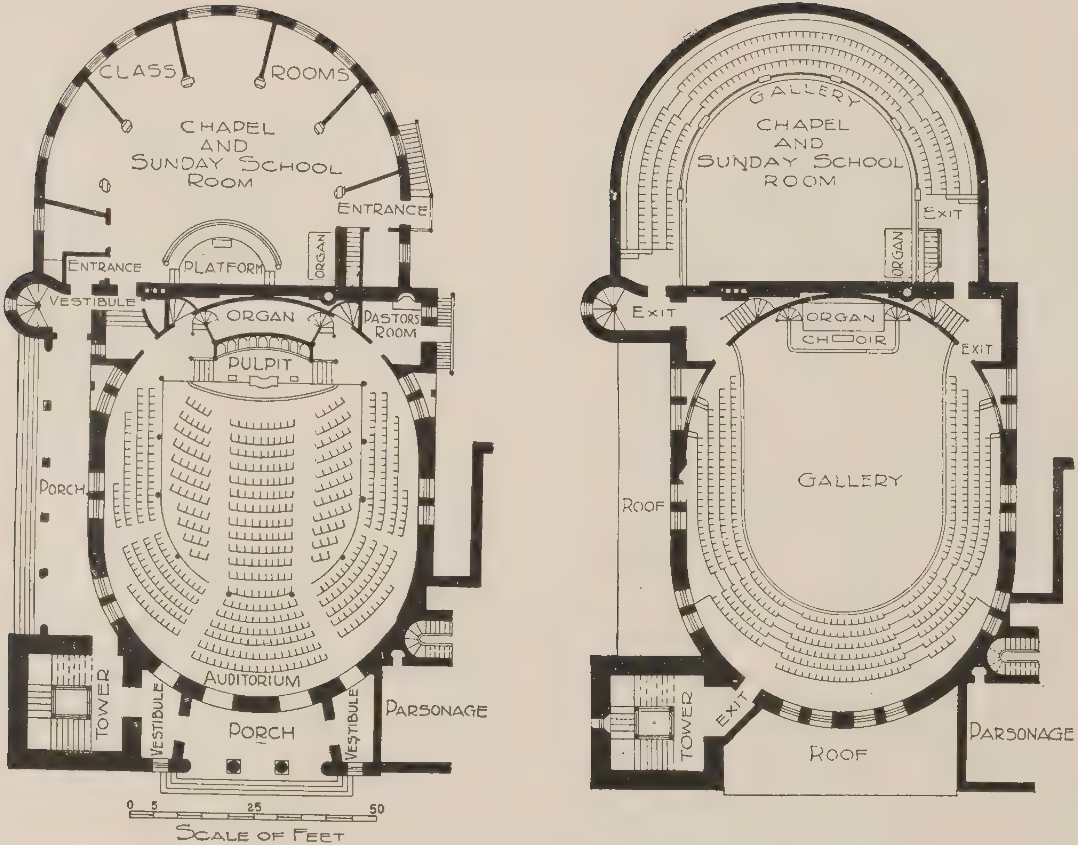


CROSS SECTION

FIRST REFORMED CHURCH, PASSAIC, N.

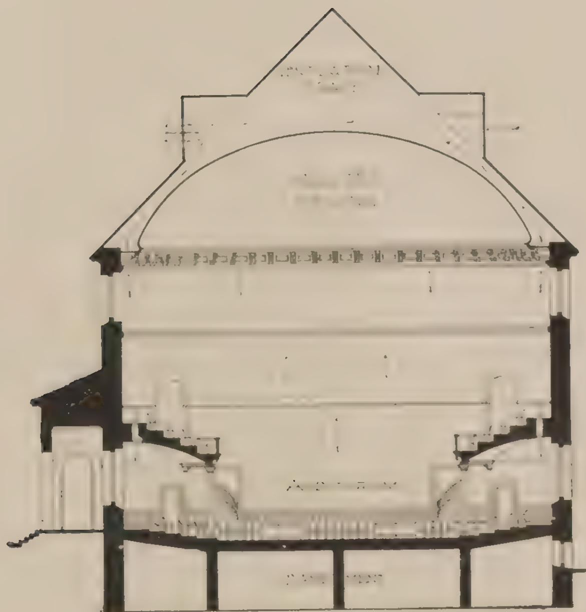
L. B. VALK & SON

PLATE XXXI



PLANS OF FIRST M. E. CHURCH, BALTIMORE, MD.

Erected in 1886-7. Seating Capacity of Auditorium, 1,400. McKIM, MEAD & WHITE, Architects.



SECTION THROUGH AUDITORIUM

FIRST M. E. CHURCH, BALTIMORE, MD.

McKim, Mead & White, Architects

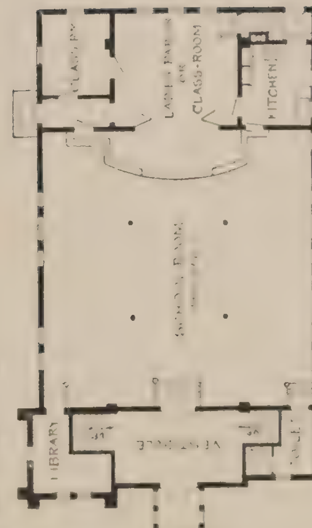
This is one of the few churches built on an elliptical plan. The general arrangement of the auditorium seems to be very satisfactory, as also the heating and ventilation. The room is subject to echoes, especially in the gallery.

The domed ceiling rises 65 feet al[illegible] to represent the heavens as they appea[illegible] church was dedicated. The audito[illegible] dows just below the base of the dome, a[illegible] The parsonage [illegible] floor plans. Building is heated by indirect steam radiation, a descripti[illegible] of the heating and ventilation being published in *The Engineer and Re[illegible]* of February 25, 18[illegible]

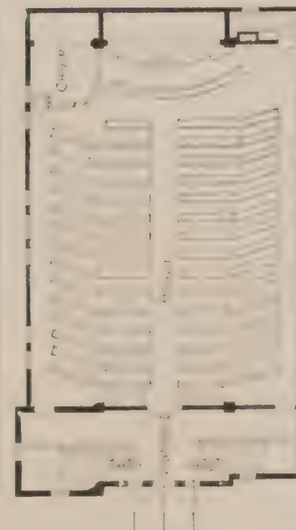
THIRD PRESBYTERIAN CHURCH, CHESTER, PA

ISAAC PURCELL, Architect.

PERSPECTIVE VIEW.



FIRST FLOOR.



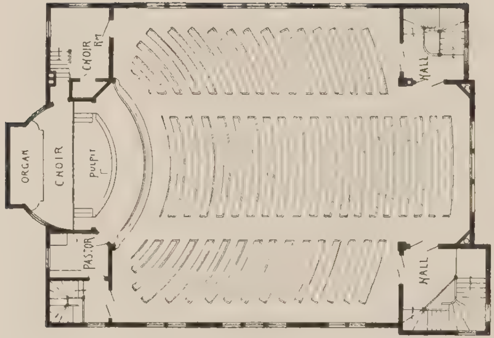
SECOND FLOOR.

DESIGN K.

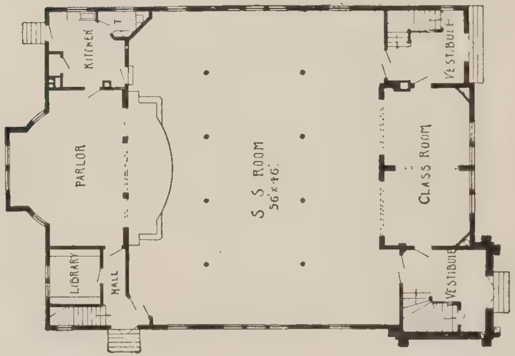
This design is for a two-story wooden church. [illegible] give the greatest accommodation for the cost of any design shown.

F. E. KIDDER, Architect.

PERSPECTIVE VIEW.



SECOND FLOOR.

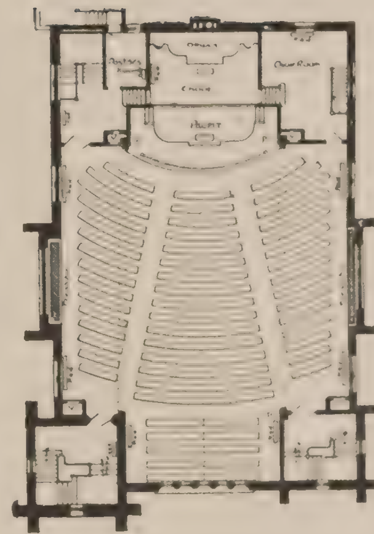


GRACE M. E. CHURCH, CAMBRIDGEPORT, MASS.

Erected 1887. Cost (in wood) $17,500. Seating capacity: pews, 480; gallery, 100.

F. E. KIDDER, Architect.

FIRST FLOOR



SECOND FLOOR

CHRIST M. E. CHURCH, DENVER, COLO

KIDDER & HUMPHREYS, Architect[illegible]

[illegible] White stone with red stone tr[illegible]gs. Cost, about $55,000. Size of build[illegible] [illegible]ojections, 60x90 feet. Extreme dimensions, 74x101 feet. Height of spire, 190 fe[illegible] [illegible] pews, 520; gallery, 170. This is a very handsome church, both inside and ou[illegible] [illegible]

ST. JAMES M. E. CHURCH, DENVER, COLO.

F. E. KIDDER, Architect.

Erected 1891. Built of pressed brick, with sandstone trimmings; pine finish, grained. Cost, $16,000, not including pews or furnishings.

For its cost, this is the most commodious brick church that the author has yet built.

The pews on the church floor will seat 550, and provision has been made for placing galleries in each of the three arms, which will increase the seating to 1,000.

The first floor will amply accommodate a Sunday school of 600 pupils, and is well arranged for socials and entertainments. The exits are abundant. The building is heated by two hot air furnaces, located in the cellar, and special provision is made for ventilation.

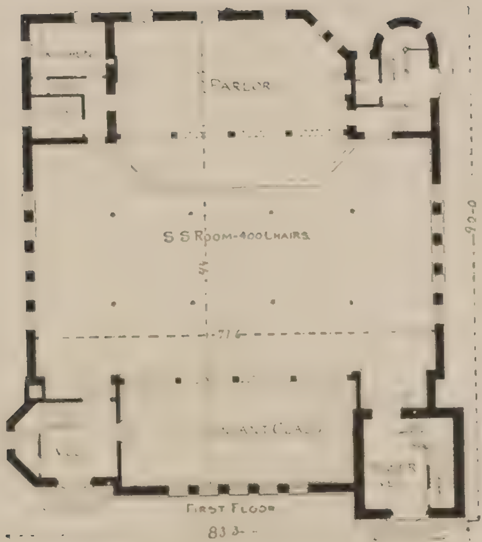
·FIRST FLOOR PLAN·

·SECOND FLOOR PLAN·

FLOOR PLANS, ST. JAMES M. E. CHURCH, DENVER, COL

ASBURY M. E. CHURCH,

DENVER, COLO.



FIRST FLOOR.

SECOND FLOOR.

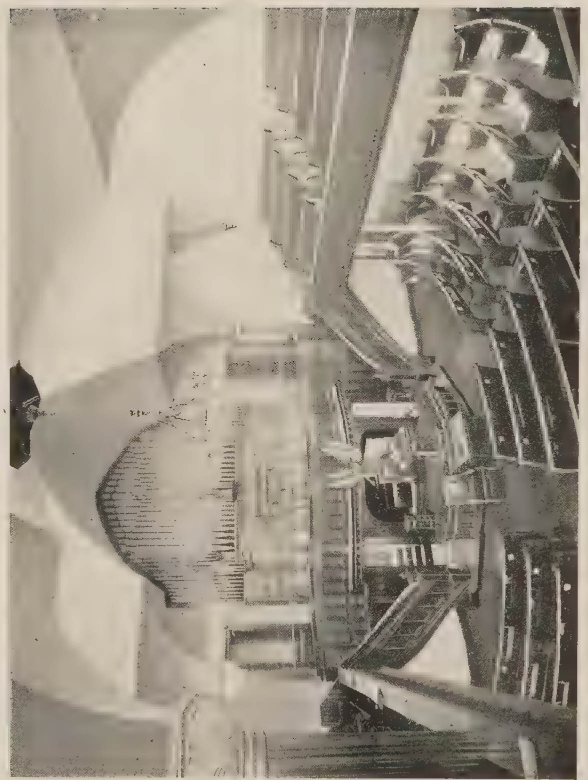
ASBURY M. E. CHURCH, DENVER, COLO.

[illegible]

INTERIOR, ASBURY M. E. CHURCH, DENVER, COLO.

KIDDER & HUMPHREYS, Architects.

INTERIOR ST. PAUL'S METHODIST EPISCOPAL CHURCH, NEW YORK CITY.



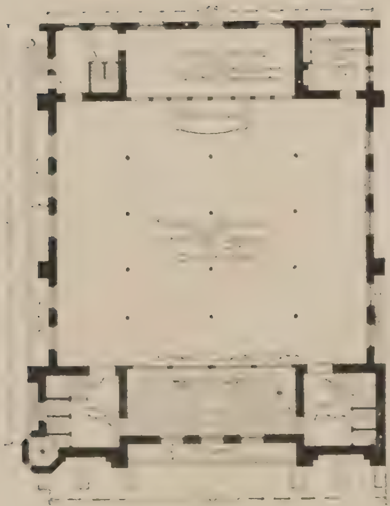
EXTERIOR AND INTERIOR VIEWS,

NINTH STREET CHRISTIAN CHURCH,

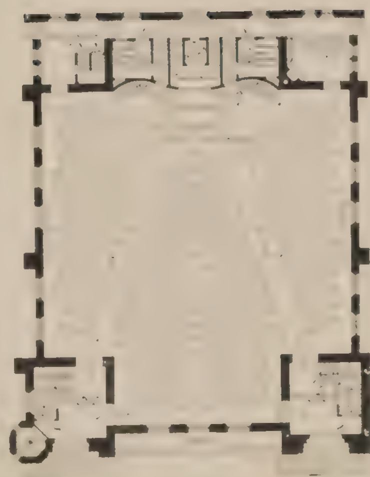
WASHINGTON, D. C.

L. B. VALK & SON, Architects,

PLATE XLIV



BASEMENT

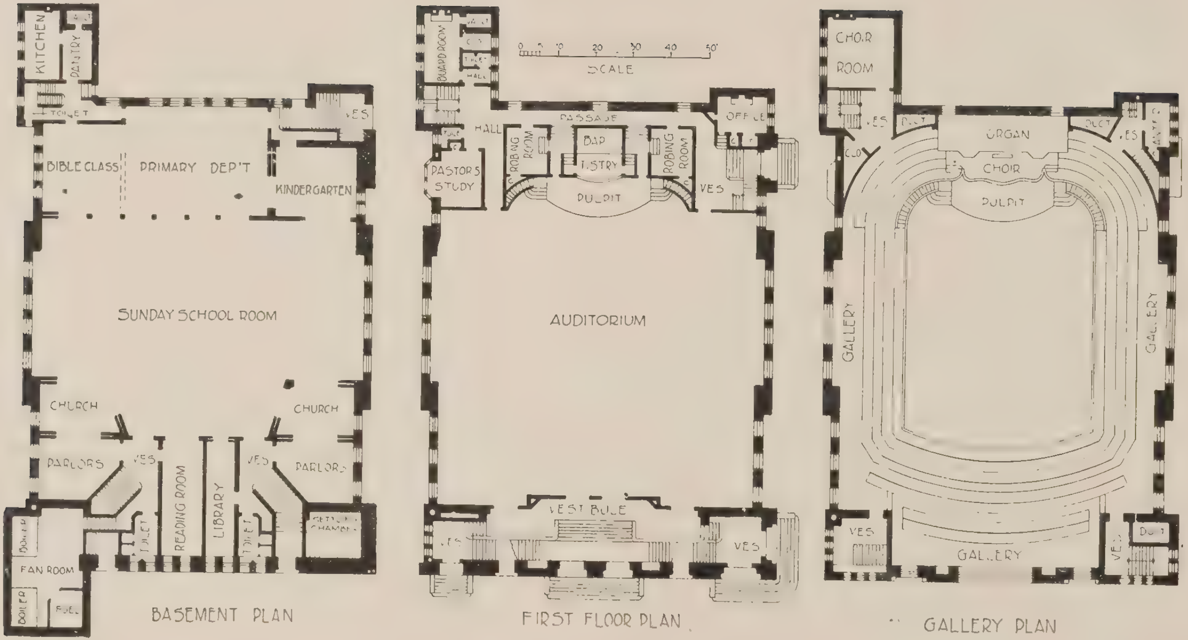


FIRST FLOOR

PLANS OF THE NINTH STREET CHRISTIAN CHURCH

WASHINGTON, D. C.

PLATE XLV



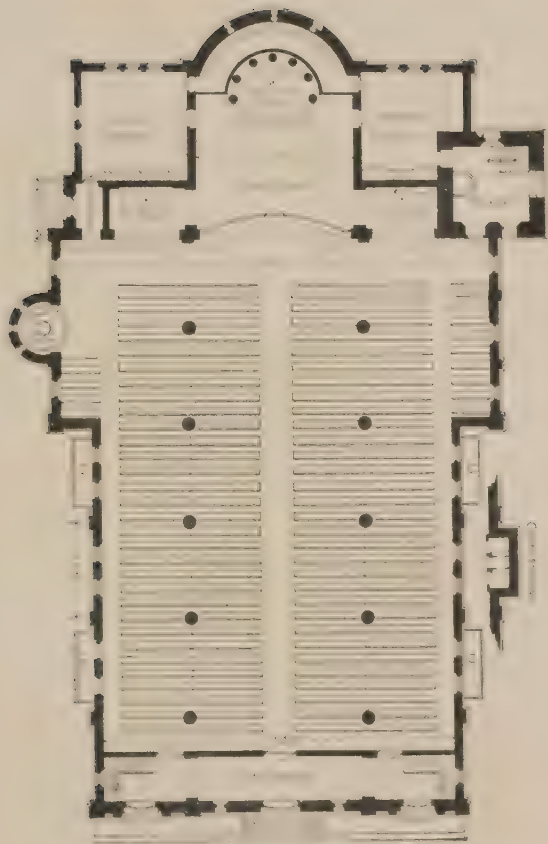
PLANS OF FIRST BAPTIST CHAPEL, BROOKLYN, N. Y.

G. W. KRAMER, Architect

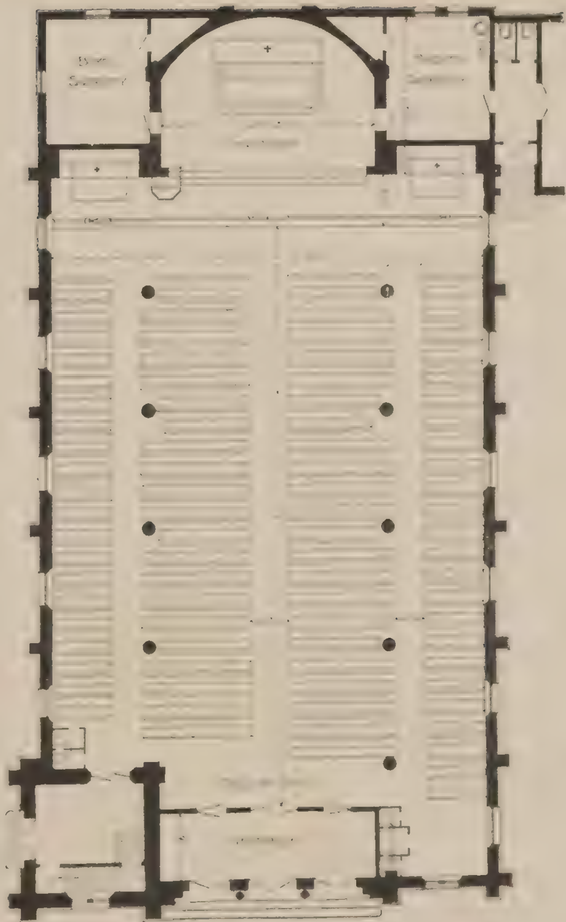
Built in 1895-6, at a cost of $62,700, including Heating, Glass and Decoration. Organ and Seating cost $9,560 additonal.

Cubic contents, including basement and one half roof height, 600 000 cubic feet. Seating capacity about 2,000.

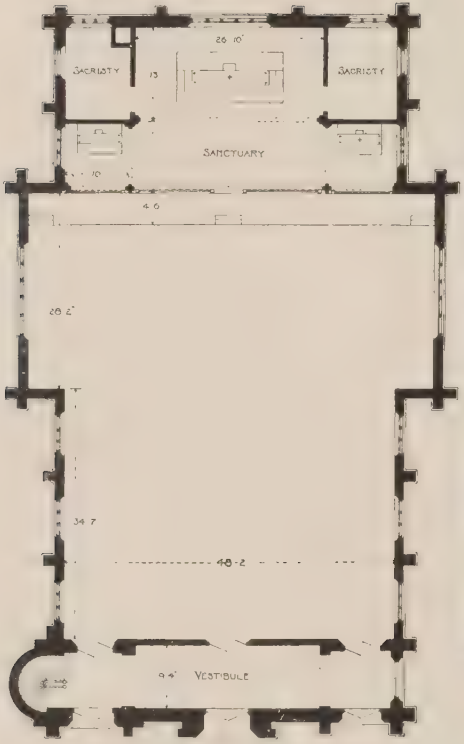
For interior view, see fig. 11 A.



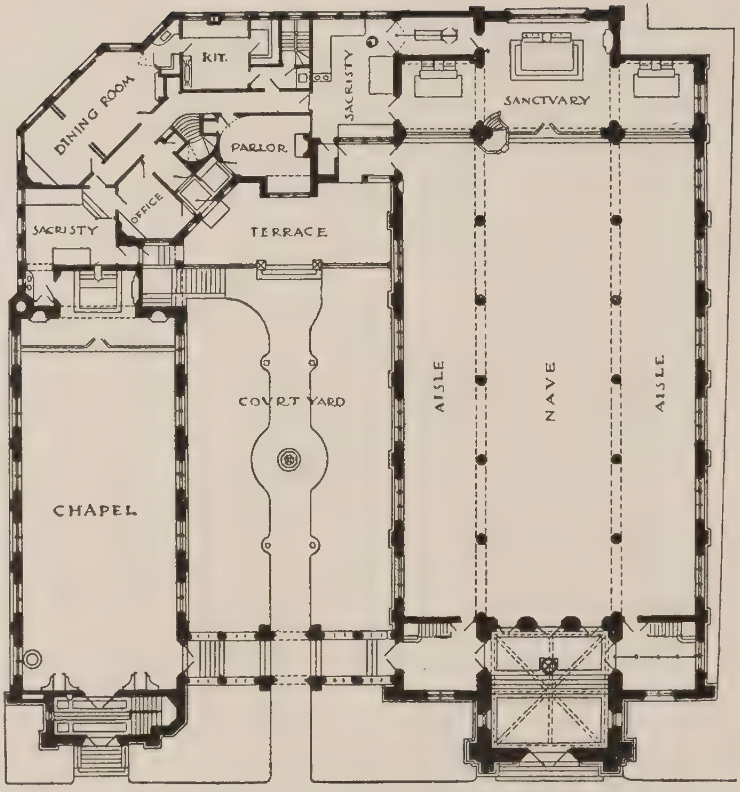
PLAN OF ST. JOHN THE BAPTIST R. C. CHURCH,
PITTSBURG, PA.
BLEZER BROS., Architects.



PLAN OF R. C. CHURCH DENVER, COLO.
F. W. PAROTH, Architect.

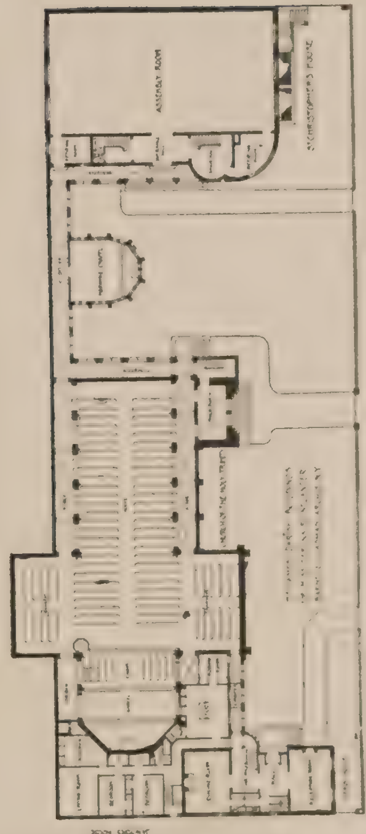


PLAN OF ST. FRANCIS R. C. CHURCH,
HARRISBURG, PA.



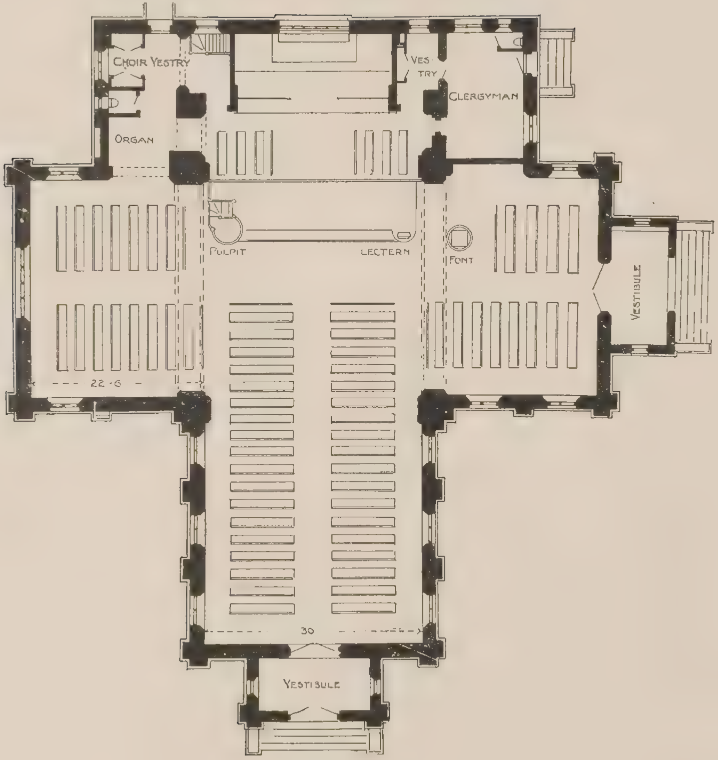
PLAN OF ST. LEO'S R. C. CHURCH, LEOMINSTER, MASS.
MAGINNIS, WALCH & SULLIVAN, Architects.

R. C. CHURCH, LAYMONT, COLO.
F. W. PAROTH, Architect

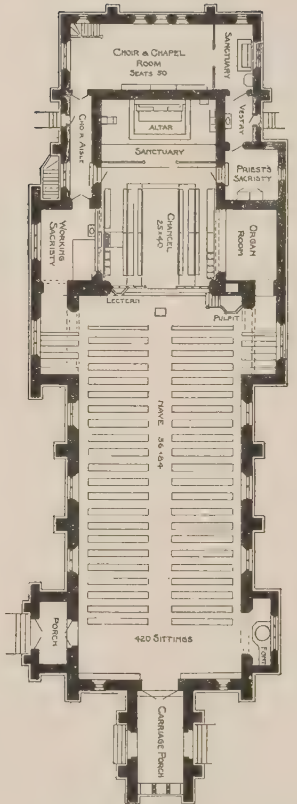


GROUND PLAN, ST. JOHN'S PARISH BUILDINGS
BARNEY & CHAPMAN, Architects

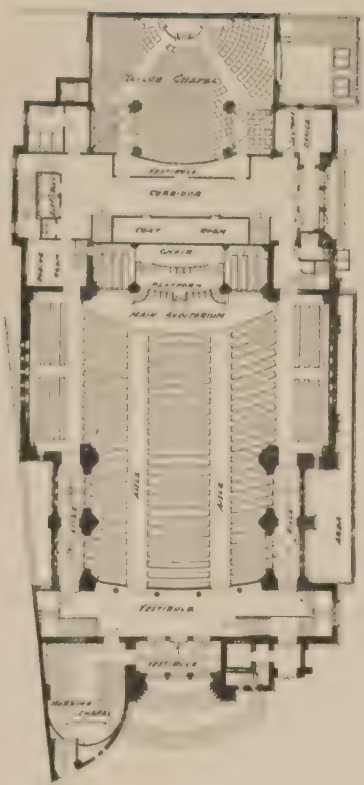
PLATE XLIX



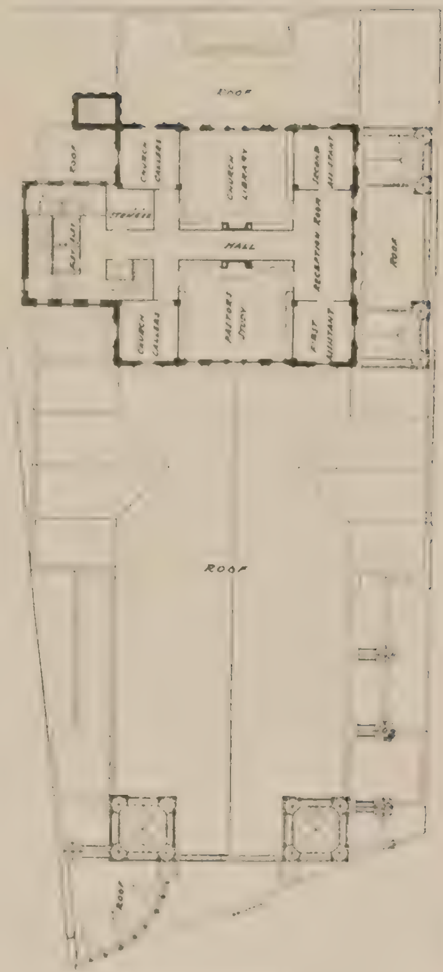
PLAN OF CHURCH (EPISCOPAL)
STOCKTON, CAL.



PLAN OF ALL SAINTS CHURCH (EPISCOPAL)
SYRACUSE, N. Y.
HENRY M. CONGDON, Architect



MAIN FLOOR PLAN.



PLAN SHOWING PASTOR'S SUITE

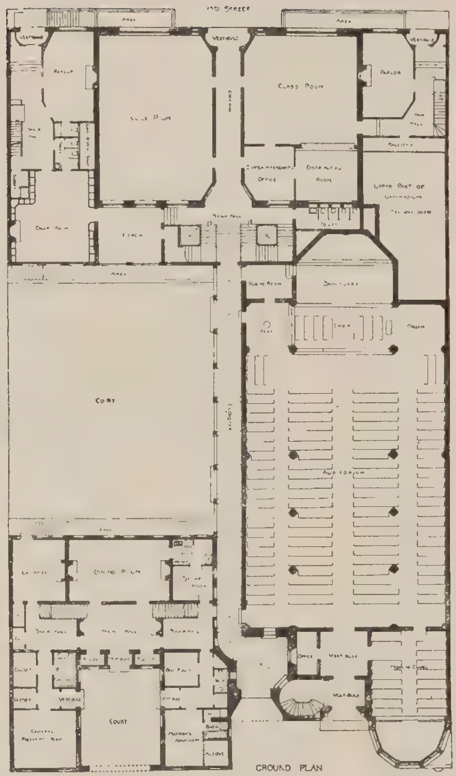
PLANS OF BROADWAY TABERNACLE.

THE BROADWAY TABERNACLE.
Broadway and 56th St., New York City.
CHAS. A. COWEN & Co., Builders. BARNEY & CHAPMAN, Architects
Organ built by Hutchings Votey Organ Co.

PLATE LII

THE BROADWAY TABERNACLE

Broadway and 56th St., New York City — BARNEY & CHAPMAN, Architects.



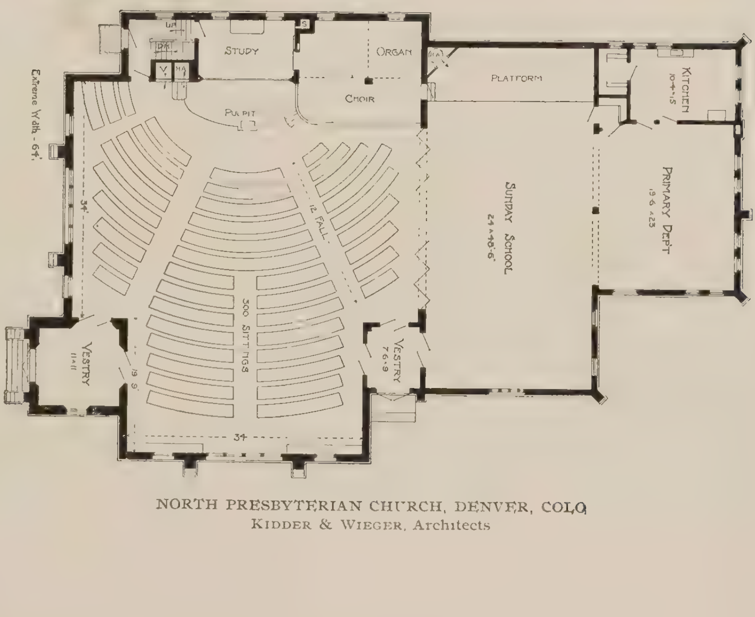
THE NEW GRACE CHAPEL AND MISSION BUILDINGS, EAST 14TH ST., NEW YORK.

Used by permission of "*Architectural Record.*"

BARNEY & CHAPMAN, Architects.

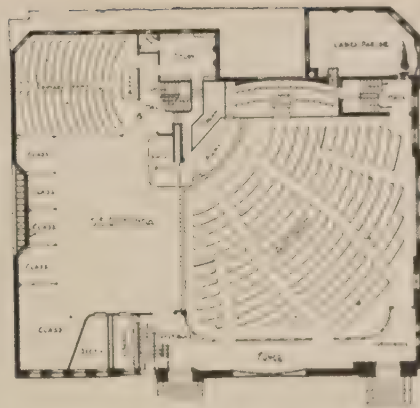
INTERIOR ... CHURCH, WEST END AVE., NEW YORK CITY

Chas. C. Haight, Architect. Reproduced by permission of the ...

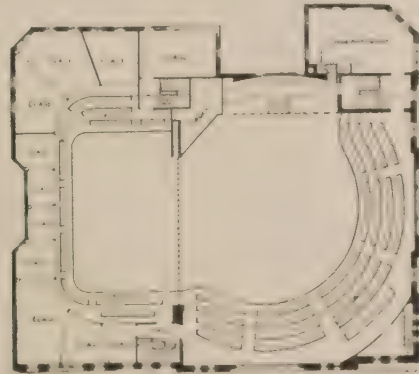


NORTH PRESBYTERIAN CHURCH, DENVER, COLO.
KIDDER & WIEGER, Architects

THE PARK CONGREGATIONAL CHURCH,
8TH AVE. & 2D ST.,
BROOKLYN, N. Y.



MAIN FLOOR PLAN



SECOND FLOOR PLAN

Reprinted from "*Architects' and Builders' Magazine*"

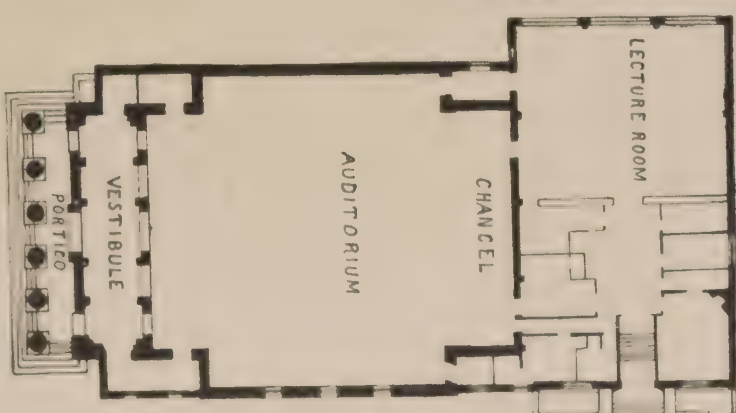
KRAMER & HAMILTON, Architects

INTERIOR OF SUNDAY SCHOOL ROOM—PARK CONGREGATIONAL CHURCH.

Reprinted from "*Architects and Builders Magazine.*"

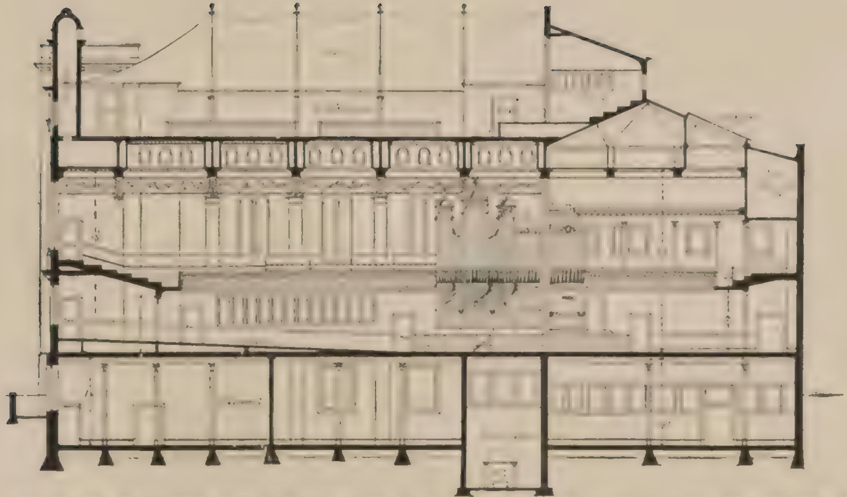
KRAMER & HAMILTON, Architects.

MADISON SQUARE PRESBYTERIAN CHURCH, NEW YORK.
McKIM, MEAD & WHITE, Architects.



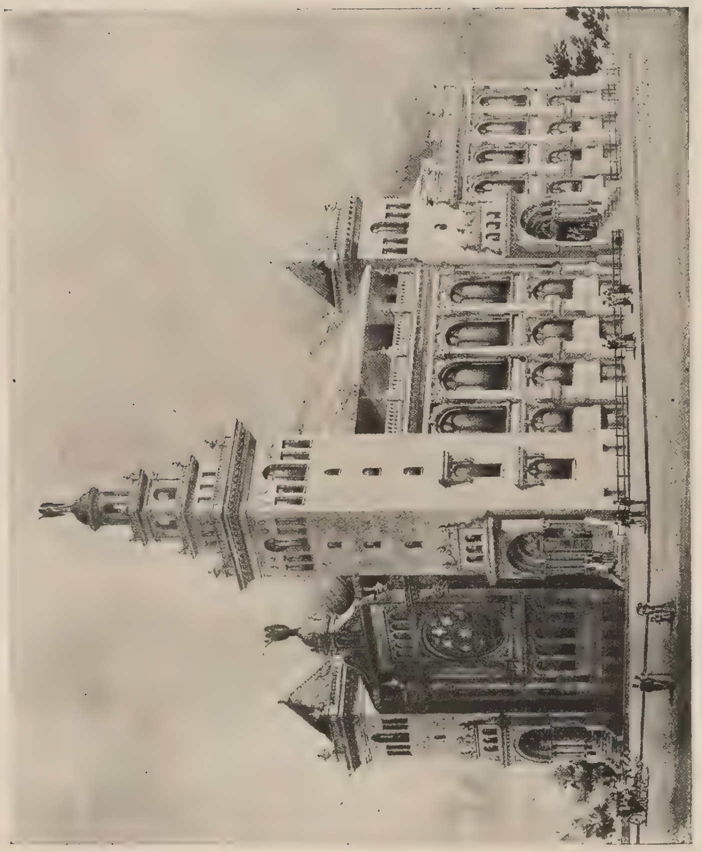
INTERIOR TRINITY M. E. CHURCH, DENVER, COLO.

Erected 1888. ROBERT S. ROESCHLAUB Architect

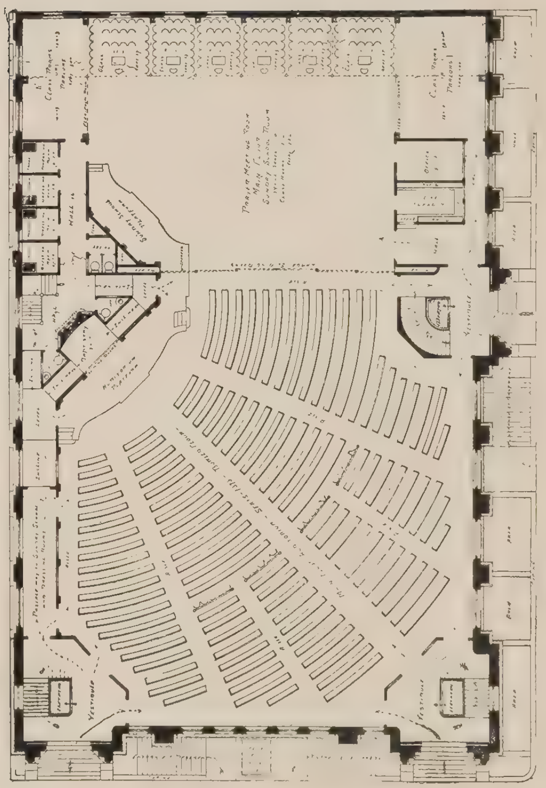


A CHURCH WITH ROOF AUDITORIUM

The section on this page and the plans on the two following pages, represent a new departure in church building the distinctive feature being an auditorium on the roof, for open air service during the hot summer months. The design is from the office of L. B. VALK & SON, and a more complete description with additional illustrations may be found in the *Architects' and Builders' Magazine* for April 1900. The building covers a city lot, 100x150 feet, and is estimated to cost about $150 000. The roof auditorium is covered with an immense canvas canopy which is removed during the winter. Aside from the roof [illegible] as an [illegible] example of the [illegible] plan for a large city church. The seating capacity [illegible] for a similar building have been adopted by Rev. A. C. Dixon of Brooklyn, N. Y.



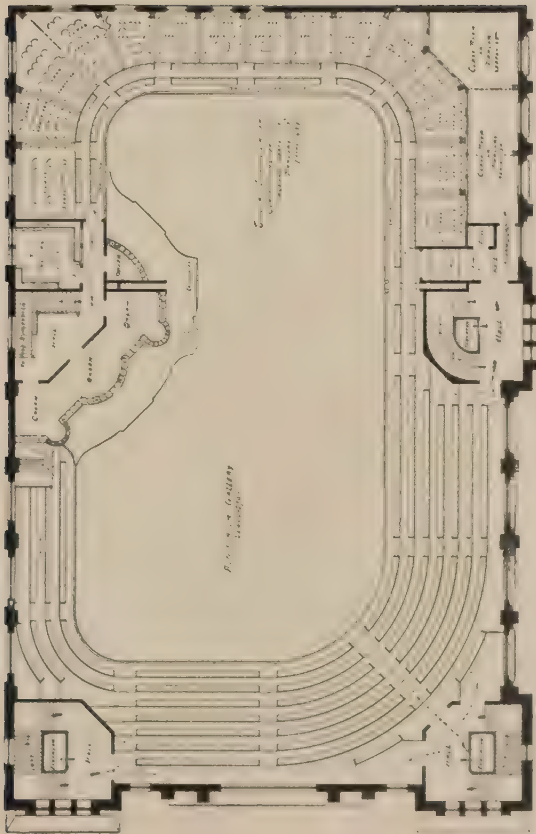
VIEW OF CHURCH WITH ROOF AUDITORIUM



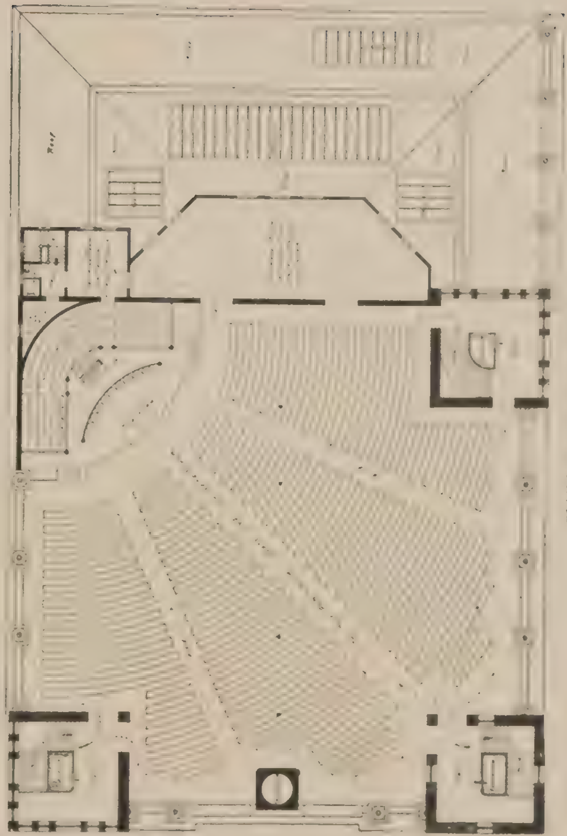
PLAN OF MAIN FLOOR.

J. B. VALK & SON, Architects.

PLATE LXII



PLAN OF AUDITORIUM AND SUNDAY SCHOOL GALLERY



PLAN OF ROOF AUDITORIUM

L. B. VALK & SON, Architects.

SYNAGOGUE B'NAI BRITH,

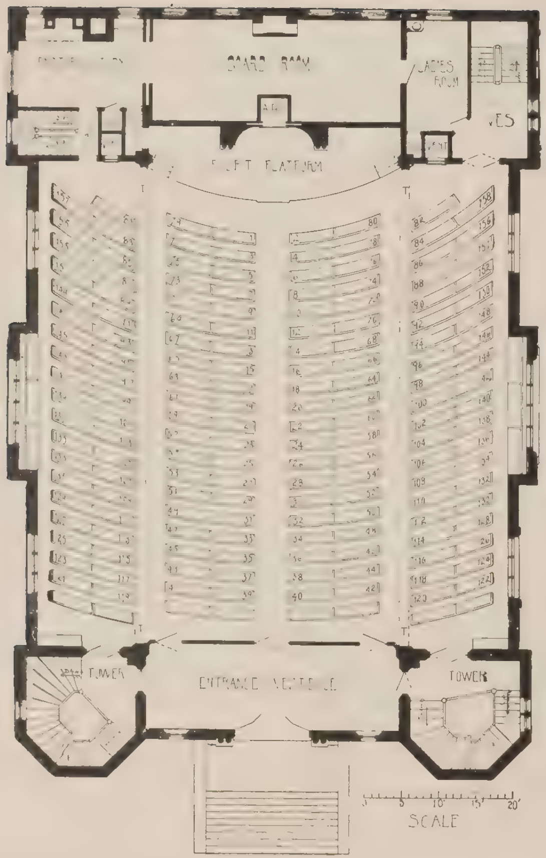
LOS ANGELES, CAL.

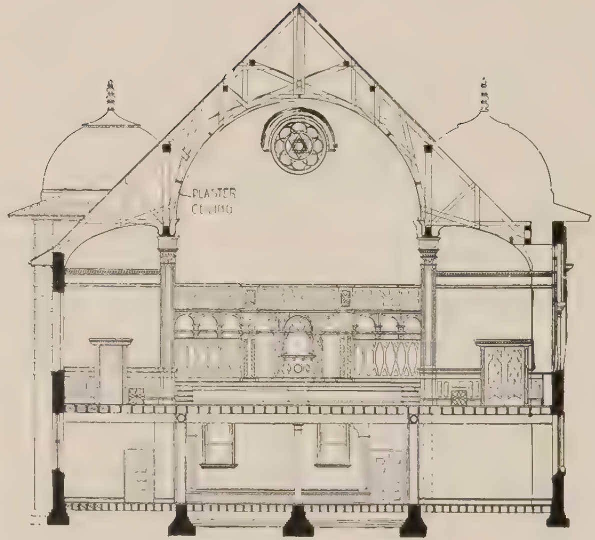
A. M. EDELMAN, Architect.

TEMPLE EMANUEL (SYNAGOGUE), DENVER, COLO.

JOHN J. HUMPHREYS, Architect. F. E. KIDDER, Eng'r. and Sup't.

Light Pressed Brick, Gray Stone and Galvanized Iron Trimmings. Erected 1898. Cost about $30,000.





FLOOR PLAN AND SECTION

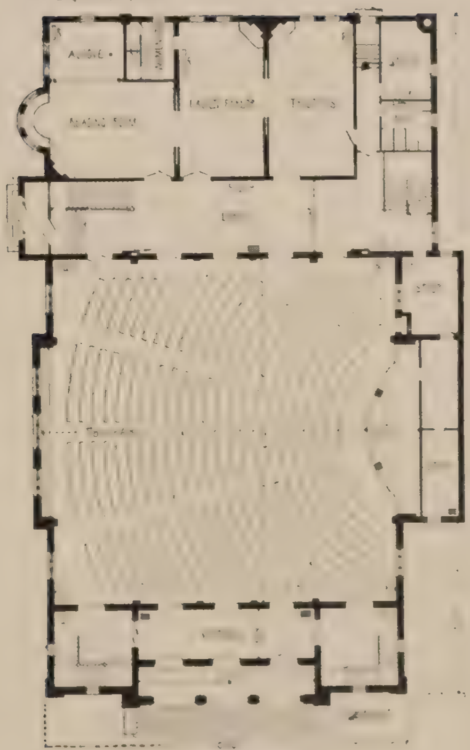
TEMPLE EMANUEL (SYNAGOGUE), DENVER, COLO.

JOHN J. HUMPHREYS, Architect.

Seating Capacity: floor, 632; gallery, 117.

Sunday School in basement.

PLATE LXVI



FIRST FLOOR

GALLERY AND SUNDAY SCHOOL

PLANS OF THE TEMPLE, CLEVELAND, OHIO

SYNAGOGUE OF THE TIFERETH ISRAEL CONGREGATION.

Erected in 1894.

LEHMAN & SCHMITT

THE TEMPLE, CLEVELAND, OHIO.

LEHMAN & SCHMITT, Architects.